TEA RESEARCH ASSOCIATION

ANNUAL SCIENTIFIC REPORT
1967-68
(1st April 1967 to 31st March 1968)

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Tocklai Experimental Station
Jorhat-8, Assam, India.

October 1968

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ANNUAL SCIENTIFIC REPORT FOR 1967-68

Organisation :

On the 31st March 1968 the Senior Staff consisted of :-

Director	...	D. H Laycock, M.B.E., M.Sc, A.I.C.T.A.
Administration :		
Adminstrative & Finance Controller	..	M. K. Choudhuri, B Com. Cal , A C.A.
Accounts Officer	. .	S. Majumdar, B Com. Cal , A C A.
Station Engineer	.	G. B Sr.ch. A.M.I S.E.
Agriculture Department :		
Senior Agriculturist	. .	K. N. Sharma, B Sc Ag., M.Sc. B.H.U. , Ph D Mich U S.A. Assoc. I A R I
Agriculturist . .	...	S. C Barua, B.Sc. Cal
Soils Department :		
Soil Chemist	...	S. K. Dev, B.Sc. Cal , Assoc. I.A.R.I.
Botany Department :		
Senior Botanist	...	D. N. Barua, B.Sc. Cal , Ph D Cantab
Plant Physiologist	...	W. Hadfield, B Sc. Hons. Liv
Plant Breeder	...	H. P. Bezbarua, M.Sc. Gau
Entomology Department :		
Entomologist	...	B. Banerjee, M Sc. Cal , M S. S. Illins , Ph D. London
Mycology Department :		
Mycologist	...	G. Satyanarayana, B Sc. Hons (Andhra) Ph.D. Mad . F B S.

Pesticide Department :		
Pesticide Testing Officer	...	T. D. Mukerjea, B.Sc. (Alhd), Ph.D. (London), Assoc. I.A.R.I
Biochemistry Department :		
Biochemist	...	S. B. Deb, M.Sc. (Cal)
Manufacturing Advisory & Tea Tasting Department :		
Manufacturing Adviser & Tea Taster	...	R. Choudhury, B.Sc. (Cal)
Engineering Development Department :		
Senior Research Engineer	...	D. N. Barbora, B.Sc.Mining, (Banaras), M.Sc.Eng. (London) D.I.C
Second Research Engineer	...	T. C. Barua, B.Sc. Hons. (Gau) B.Sc. (Mech. Eng.) Banaras, M.Sc. Mech. Eng. (Manchest)
Statistics Department :		
Statistician	...	A. K. Biswas, M.Sc. (Gau)
Advisory Department :		
Chief Advisory Officer	...	S. K. Dutta, B.Sc. Hons. Bom) B.Sc. Wales)
Assam		
South Bank		
Advisory Officer	...	S. Basu, B.Sc.Ag. Hons. (Delhi), Assoc. I.A.R.I.
Advisory Officer	...	S. K. Sarkar, B.Sc. (Cal), B.Sc. Ag. (Banaras)
Advisory Officer (Designate)	...	B. C. Barbora, B.Sc.Ag., M.Sc. (Agronomy) I.A.R.I.
North Bank :		
Advisory Officer	...	P. C. Sharma, M.Sc. (Banaras), Ph.D. (London), F.L.S.
Cachar		
Advisory Officer	...	T. K. Ghose, B.Sc.Ag. (Pat), Assoc. I.A.R.I., Ph.D. (Cornell)

West Bengal :

Chief Advisory Officer West Bengal	...	W. J. Grice, M.A. Dip Ag. Cantab,
Advisory Officer, Dooars	...	F. Rahman, M.Sc.Ag. (Bihar), Ph.D. (I.A.R.I., New Delhi
Advisory Officer, Darjeeling & Terai	...	H. Mitra, B.Sc. (Cal,

West Bengal Experimental Station : (Mal)

Officer-in-Charge	...	N. B. Chanda, M.Sc. Dac., Ph.D. Edin.

SENIOR STAFF MATTERS

Appointments—Mr. H. P. Bezbaruah joined as Plant Breeder on the 2nd January 1967. Mr. B. C. Barbora joined as an Advisory Officer on 2nd January 1968. Mr. S. Mazumdar joined as an Accounts Officer on 1st February 1968. Mr. T. C. Barua was appointed as the Second Research Engineer on 4th March 1968. Mr. M. K. Choudhuri was designated as Administrative & Finance Controller on 19th March 1968.

Resignations—The following Officers left the Association's service during the year on the dates shown against their names : Mr. A. C. Bordoloye, Second Research Engineer on the 17th July. Mr. S. K. Banerjee, Second Tea Taster on the 13th December.

Retirement—Mr. J. R. Gee-Smyth, Administrative Controller left the Station on retirement on the 19th March, 1968.

CONFERENCE

The Twenty Third Conference was held at Tocklai from the 7th to 9th November, 1967.

COURSES

The following Lecture Courses were held during 1967 :-

(1 **Vegetative Propagation Course**

1st Course - 29th May to 2nd June - 22 planters attended
2nd Course - 5 th June to 9th June - 27 planters attended

(2) **Field Management Course**

1st Course – 3rd to 7th July – 25 planters attended
2nd Course – 10th to 14 July – 20 planters attended
3rd Course – 17th to 21st July – 22 planters attended

(3) **Agricultural Chemical Course**

1st Course – 31st July to 2nd August – 18 planters attended
2nd Course – 7th to 9th August – 27 planters attended

(4) **Factory Management Course**

1st Course – 21st to 25th August – 18 planters attended
2nd Course – 28th Aug to 1st Sept. – 26 planters attended

TRAINEES

Seven employees of Member estates, one from Non-Member estates and one Turkish National attended and completed their One year Training Course at Borbhetta. Eleven students joined the V. P. Training Course out of which seven completed the course.

VISITORS

Some of the Visitors, in addition to local planters who are listed below :-

Dr. Eric F. W. Dux, M S Lyons & Co. Ltd., London.
Mr. & Mrs W. Kenneth Warren, M S James Warren & Co. Ltd., London
Mr. R. W. Palmer, Alex Lawrie & Co., Ltd.
Mr. J. D Willis, M S Balmer Lawrie & Co Ltd., Calcutta.
Mr. P. M. Glover, M S James Warren & Co Ltd.
Mr. G W. U. Liddle, M B.E., M S Gillanders Arbuthnot & Co Ltd, London
Mr. Baldev Singh, C.S.I.R., New Delhi.
Mr. R. I. Macalpine, M S McLeod & Co. Ltd., Calcutta.
Dr. Dietrich Divel, University of Hamburg, W. Germany.
Mr. Carel H. Van Velthuyzen, F. M. C. International, New York.
Mr. F. R. J. Bagley, M.B.E., M S McLeod & Co. Ltd., Calcutta.
Mr. Mrs. J. E. Farrel, New Zealand High Commission, New Delhi.
Sir Owain Jenkins & Party - The Assam Co. Ltd.
Mr. J. A. Morice, M S Williamson Magor & Co. Ltd., Calcutta.
Mr. Kigoshi Katsuo, Makurazaki, Kagoshima, Japan.
Mr. Shun Amma, Makurazaki, Kagoshima, Japan.
Mr. R. C. N. Scott, James Finlay & Co. Ltd., Calcutta.
Mr. E. Hainsworth, Tea Research Institute of East Africa.
Dr. R. T. Ellis, Tea Research Institute of Central Africa.
Mr. P. K. Kanoria, Tea Research Association, Calcutta.

Mr. P. G. Gordon Smith, Moran Tea Co. Ltd., London.
Mr. J. F. Hay, Moran Tea Co. Ltd., London.
Mr. N. S. Bedi, M S Dunlops, Calcutta.
Mr. S. Das M/S Dunlops, Calcutta.
Mr. H. R. R. Seetle, Bombay Burmah Trading Corporation Ltd., South India.
Mr. R. K. Kamal, D.C.S. Development, N. F. Rly.
Mr. P. V. B. Sarma, D.C.S., N. F. Rly., Dibrugarh.
Dr. Natadermadi, Asian Development Bank, Manila.
Mr. G. P. Shrivastav, Tea Board, Delhi.
Mr. Kiyoshi Komai, Kawasaki Iron Works, Japan.
Mr. Takashi Harada, Terada Seisakujo Co. Ltd., Japan.
Mr. Tatsuro Miyamura, Miyamura Iron Works Ltd., Japan.
Mr. Sojiro Sano, Matsushitakojo Co. Ltd., Japan.
Mr. Mitsuo Kushida, Nagoya Air & Tourist Branch, Japan.
Mr. & Mrs. E. D. Maguire, Davidson & Co. Ltd., N. Ireland.
Mr. J. J. Brown, Andrew Yule & Co Ltd.
Lt. Col. F. W. S. Roberts, Jorehaut Tea Co. Ltd., London.
Dr. B. P. Pal, The Barooah Committee Member.
Dr. O. P. Gautam, The Barooah Committee Member.
Mr. P. C. Barooah, The Barooah Committee Member
Mr. K. S. Verma, The Barooah Committee Member.
Mr. H. C. Bannerman of Macneill & Barry Ltd., London.
Mr. J. E. M. Turpin, Macneill & Barry Ltd.
Mr. R. G. Marlow, 1st Secretary, Commercial British High Commission, Calcutta.
Mr. H. Ferguson, James Finlay & Co., Glasgow.

ADVISORY DEPARTMENT
ASSAM

1. Visits

The demand for advisory visits increased in all the three main districts i.e. South Bank, North Bank and Cachar. Estates, especially those which have joined T.R.A. comparatively recently, were keen on seeking advice and putting it into practice and it has been gratifying to note that in most of these cases good results have been obtained.

It appears that the greatest stumbling block in following some types of advice, the results of which may not be apparent immediately, is the poor economic conditions of some estates. For example, an estate with little scope for extension, hesitates to keep areas due for replanting two years under a rehabilitation crop after uprooting, although it realises that as a long-term policy, such a treatment could definitely be a paying proposition. Many estates, for the same type of reasons, are hesitant to use herbicides.

Routine advisory visits made by the Advisory Officers were as follows :-

Areas	Total No. of visits	No. of estates visited
South Bank	242	140
North Bank	136	65
Cachar	83	32

In addition, visits were made in connexion with the conduct of field experiments as follows :-

South Bank — 59 visits
North Bank — 13 ,,
Cachar — 23 ,,

2. Field Management Practices

(a) **Drainage :** There is a growing awareness of the importance of drainage and much work on it had been started in many estates. The major obstacle and problem encountered in so much drainage work is the lack of suitable outlets during the rains. In Cachar, the situation has become worse as a result of silting up of river beds, and there is a considerable backing up of flood water from the rivers into the flat lands following heavy rains in the hills. This situation is causing great concern.

The importance of contour surveys is being impressed upon managements and the necessity for contour drains, both for effective drainage and

a measure against soil erosion, is also being gradually realised whenever new planting or replanting is undertaken. Lack of adequate surveying equipment and personnel with a sufficient practical knowledge of modern drainage methods, frequently hampers the laying out of effective drainage systems.

(**b**) **Pruning cycle:** Most estates in the Assam Valley have welcomed the introduction of longer pruning cycles and the area under skiff has risen considerably. Planters are generally convinced that the quality and the appearance of made tea are not affected by deep skiffing but they are as yet uncertain as to what the effects of medium skiffing are on their teas manufactured by either CTC or Orthodox methods.

On the North Bank, many estates continued to deep skiff at 12.5 cm (5") and to pluck over 7.5 cm (3") of new growth with good results.

In Cachar, prune—deep skiff— medium skiff or prune—medium skiff—light skiff cycle has been recommended. There is a noticeable trend, particularly so in the case of proprietory estates, to follow a longer pruning cycle with completely unpruned tea.

(**c**) **Shade :** *Indigofera teysmanii*, which was introduced to the tea industry by Tocklai only about eight years ago, and *Albizzia odoratissima* are now by far the most popular trees as temporary and permanent shade species respectively. *Albizzia lebbek*, *Albizzia lucida*, *Acacia lenticularis* and *Derris robusta* have also been recommended as permanent shade species. On the other hand, planters have been dissuaded by Advisory Officers from using *Albizzia chinensis*, *Albizzia falcata* Syn. *moluccana*, *Albizzia procera* and *Cassia siamea*.

Heavy infestation of Cerambycid grub has caused serious canker on *D. robusta* in some estates in Cachar and young *A. lucida* has been found to be very prone to canker caused by the grubs of the beetle *Agrilus beesoni* in all areas. Good protection has however been obtained from the application of lime sulphur and Dieldrex. *A. odoratissima*, *A. procera* and *A. lebbek* suffered in some estates, especially on the North Bank, from attacks of *Sternocera* root borers but good control was obtained by hand collection of eggs from July to October and by applications of Telodrin in October and March.

In some estates poor growth of shade trees could be traced to planting in small pits without adequate manuring, and planting of too small plants in mature tea sections. Applications of cattle manure, superphosphate, wood ash or other potash fertilizers, and lime to shade nurseries have been

recommended to promote vigorous growth of seedlings. Regular sprayings both in nurseries and field with Endrex or Thiodan against pests such as Membracids, psyllids, defoliating caterpillars and beetles, and with copper fungicide against red rust have also been recommended. The importance of digging deep transplanting pits and adequate manuring at the time of planting have been stressed again and again.

(**d**) **Cultivation and weed control :** Many estates have tried Paraquat (Gramoxone), Dalapon and Simazine in tea areas, and 2 4-D in non-tea areas mainly to control Mikania. One big company in Upper Assam has virtually replaced manual cultivation by spraying Gramoxone with great economic advantage. Advisory Officers have been trying to convince planters that financial benefit can be derived from continuous use of herbicides, especially in young tea areas which often cannot be kept weed free because of shortage of labour. However, the two main drawbacks to the use of herbicides are the initial high cost and the poor availability of Gramoxone which is by far the most extensively used herbicide in tea in Assam. Suitable machines for spraying herbicides are easily available.

The importance of mulching is realised and accepted, but most estates find it to be too expensive. Nevertheless some with more easily available labour, have tried mulching with great advantage. The Advisory Officers have advised managements to establish mulching crops such as *Eragrostis curvula* (Weeping Love grass) and *Tripsacum laxum* (Guatemala grass) in all un-utilized areas of estates, so that material for mulching is more readily and cheaply available.

Damage to the collars of young tea caused by the cheel hoe is very common, though managements have been repeatedly advised to do hand weeding only around the collar of young tea plants. The formation of high ridges inbetween the tea hedges, due to faulty cultivation is often seen and in one estate on the North Bank, soil samples were analysed from the ridges and depressions and it was found that the available quantities of phosphate and potash were far more in the former than in the latter where most of the feeding roots are.

(**e**) **Manuring :** Most estates have accepted the revised Tocklai recommendations on manuring and the majority of requests for advice were mainly in connexion with the changes involved, particularly on how to convert Y.T.C. mixture to Y.T.D.

(**f**) **Pruning of young tea :** Death of plants, especially in the case of clones, was reported form several estates following pruning and centering at the generally accepted pruning time from the end of January to early

February. The cause of death has been attributed to a total absence of starch reserves in the roots at the time of pruning, and consequently planters are now being advised to carry out the iodine test for starch before starting pruning and centering. Excellent results have been obtained wherever this advice was followed.

(g) **Other field management practices :** Advice was also sought on nursery techniques (both seeds and clones), control of pests and diseases, spacing of tea, green crops and ground cover crops, grasses for soil rehabilitation, maintenance of clonal multiplication plots etc.

3. Pest and Disease Control

There has been a general decline in red spider and other mite attacks in the Assam Valley but serious looper caterpillar and green fly attacks were reported from several estates. Incidence of *Lymantrid* caterpillar, red slug and *Lawana conspersa* was reported from the North Bank, and of red spider, scarlet mite, purple mite and helopeltis from Cachar.

Red rust in all regions continues to be the most common disease in tea and the reasons for its prevalence are many, such as general debility of plants in replanted sections, lack of shade, the use of red rust susceptible green crops (viz. *Tephrosia candida*), inadequate drainage and last but not the least insufficient chemical spray control. Black rot incidence was heavy in many estates in the Assam Valley and Cachar from July to September Spraying against black rot is often not given much attention, one reason being that the spraying schedule against black rot coincides with the heavy cropping period and thus managements find it difficult to divert labour from plucking onto spraying. There are instances where thinning out of shade and both prophylactic and palliative sprayings resulted in an immediate economic increase in yield. As regards blister blight, its sporadic incidence was reported only from a few estates in Cachar and on the South Bank.

Sun scorch damage was quite severe in August-September in some estates on the South Bank. The damage is known to take place in poorly shaded areas when hot sunny dry and cloudy wet spells alternate. But two other factors were common to all the cases examined and those were, too high water-tables and light-leafed Assam *jats*.

A sufficient number of power sprayers is not available in many estates although there appears to be no shortage of suitable equipment on the market. Hence in the case of an epidemic, such as that of looper caterpillar, a considerable loss in crop is inevitable. A few estates who have bought adequate

power sprayers at the insistence of Advisory Officers have realised the cost of machines in the very first season.

Spraying techniques and maintenance of the machines are often incorrect and much improvement is needed.

The supply position of some of the important pesticides such as Tedion, Kelthane and Telodrin continues to be inadequate and causes great concern. Planters have been advised to place orders for pesticides well ahead of schedule and as a safeguard, alternative chemicals such as Ethion, Trithion, Morocide and Thiodan have been recommended.

4. Extension, Uprooting and Replanting

Where reserve land is available, the accent is more on extension planting than on replanting. The reasons are to some extent political but mainly a matter of economics. The uprooting and replanting situation is particularly critical in estates where land for extension is not available, and they are in the present economic circumstances, often forced to maintain poor sections because the interim loss of total estate crop cannot be accepted The apprehension is so acute that even where replanting is a regular matter of policy, uprooted areas are often replanted without adopting any soil rehabilitation practices at all, and as a result much of the replanted tea to-day is poor and indifferent, and is predictably, causing constant worry to management and Advisory Officers. The important reasons for failure of replanted teas can be summed up as follows :-

(1) Hesitancy on the part of managements to spare uprooted areas for a period of two years for rehabilitation before replanting.

(2) Failure to establish good soil rehabilitation crops.

(3) Absence of indigenously produced tractors which are powerful enough to draw a sub-soiler to a depth of more than 55 cm. As a result, the 'pan' in the sub--soil remains undisturbed with all its undesirable effects on drainage and soil structure.

To counteract these shortcomings, the Advisory Officers have stressed the importance of using powerful tractors (55 H.P. at least) for sub-soiling and have made efforts to convince planters that rehabilitation of uprooted areas under a good green crop for at least two years pays in the long run, and for the better growth of leguminous green crops superphosphate must be used at the time of sowing seeds. The suggestions have unfortunately not been accepted as widely as hoped but in the cases where they have been, most encouraging results have been obtained. Guatemala grass and *Mi-*

mosa invisa have been recommended as improved types of soil rehabilitation crops and many estates have now established these green crops in multiplication plots and it is hoped they will in due course make the best use of them in the field.

In the Assam Valley, replanting has generally been at the rate of 2 to 3 per cent where replanting is a normal estate practice but the percentage of extension areas varied a great deal from estate to estate and, therefore, it is difficult to quote a figure. In Cachar, replanting has been virtually nil; most of the tea that is planted out every year (from 1.25 per cent in North Cachar to 2.24 per cent in Hailakandi, goes into extension and/or replacement plantings.

A bush population of about 12,345 per hectare has been generally considered as optimum but it will have to be varied between 11,111 and 13,456 per hectare depending upon the spreading habits of the plants and the fertility status of the soil i.e. when the soil is poor and or the plants have an upright growth habit, the bush population will be higher.

The two spacings which have often been suggested are 120 cm × 75 cm × 75 cm regular double hedge or 120 cm × 60 cm × 90 cm staggered double hedge, but in the steep slopes of Cachar, single hedges on the contour are still preferred.

5. Agricultural Machinery

In many estates, sub-soiling was done with a 35 H.P. wheeled tractor which can draw a sub-soiler to a depth of only about 35 cm, whereas those estates which in accordance with our recommendations, were able to use heavier tractors of 55 H.P. or more, were able to sub-soil down to 60 cm.

On a number of estates, sprinklers and other irrigation equipment have been used to irrigate young and mature tea. The exact economics of irrigation under the conditions of these estates is not known to us but the results so far obtained from a few irrigation experiments conducted by ourselves in the Assam Valley have not indicated that irrigation for yield is economical. With the present trend of having more and more of skiffed tea, the situation may however alter especially in drought prone areas, in favour of primarily survival irrigation.

6. Miscellaneous

(a) **Completely unpruned tea :** In one estate on the North Bank, the total increase in crop in the first year from leaving tea completely unpruned (without irrigation was to the extent of 34 per cent over annually pruned tea. On the South Bank, in some irrigated vigorus mature tea

areas, the average increase was to the extent of 37 per cent. In Cachar, one group of estates was able to increase its yield by over 80 per cent within a period of four years by adopting longer pruning cycles with at least 75 per cent of tea totally unpruned. Our opinion is that this large increase is not only due to the benefits of longer pruning cycles as such but also to a high standard of management.

(**b**) **Root depth :** Studies on root growth undertaken on the North Bank showed that there was considerable variation on root development depending on height of water table and soil texture. In one mature section, a high water table and stiff lower layers of soil caused the root system to be restricted to within the first 40 cm from the surface whereas in a free-drained sandy soil, the tap root of mature bushes was found to have extended to a depth of 3.4 m.

In Cachar, studies were undertaken in one estate, both on flats and teelas, to see whether unrestricted top growth could help in causing deeper root penetration. All the bushes examined were of Silbhetta origin, planted out during 1941 and brought into plucking thereafter. Some of these were selected as seed bearers in 1953 and allowed to grow unpruned, whereas the remainder were left for plucking. In terms of depth of rooting, the seed bearers on the flat appeared to be very little different from the plucked bushes and this would be expected from the effects of high water table that is normally present on such flats but on teelas, where the water table was not a limiting factor, the seed bearers had roots which penetrated deeper. It is however significant to note that spread at all sites was clearly greater for the seed bearers. Considering the total root system, it is likely that the seed bearers whether on teelas or on flats had developed more than bushes under plucking. This at first sight appears to be an effect of not pruning against frequent pruning but so far, no observations have been taken on roots under tea maintained on various lengths of pruning cycles.

Meetings

Area Scientific Committee

There are three Area Scientific Committees on the South Bank, two on the North Bank and one in Cachar. During the year, a total of 19 meetings were held as under :-

South Bank, Area (1)	— 3
" " " (2)	— 1
" " " (3)	— 4
North Bank, East	— 3
" " West	— 3
Cachar	— 5
Total	—19

By and large, the meetings were well-attended, especially in Cachar, on the North Bank and in Area 3 on the South Bank but Areas 1 and 2 on the South Bank made a rather slow beginning. The meetings proved very rewarding and helpful and they have opened new fields of contact between planters and the scientific staff. Interesting and useful discussions took place on a wide range of varied subjects.

The committee meetings are generally followed by open meetings where all planters of the local sub-area are invited to join and take part in the discussion.

ADVISORY DEPARTMENT—WEST BENGAL

GENERAL

The West Bengal Advisory Department consists of the Head Quarters office at Nagrakata where the Chief Advisory Officer, West Bengal and Advisory Officer, Dooars reside, an office in Darjeeling for the Advisory Officer, Darjeeling and Terai and a Soil Testing Laboratory at Mal with Dr. Chanda in charge. During the year Advisory Officers in the Dooars and Darjeeling concentrated on routine Advisory touring to Member estates. The Chief Advisory Officer, West Bengal, was kept occupied over the supervision and conduct of field experiments and Dr. N. B. Chanda was on a special assignment collecting yield and field management data from Member estates.

VISITS

The Advisory Officers who concentrated on routine touring, offered their services to every Member estate two to three times during the year.- A total of 344 vistis were made to 137 Member estates. The total number of Member estates in West Bengal on 31.12.67 was 178 and therefore 41 Members did not make use of our services. The table below gives the breakdown of the visits made in each district.

District	No. of visits	No. of Members visited	No. of Member estates in Dist.
Dooars	183	79	107
Darjeeling	110	43	53
Terai	51	15	18
Total	344	137	178

Of the 344 visits made 46 were made on special request and of these, 37 were actually considered of sufficient importance to have warranted a special visit.

There are definite indications that the demand for the services of the Advisory Officers is on the increase during their regular tours. However, it is disappointing to have to record that 41 Member estates did not make use of the Advisory Officers during the year. One very satisfying aspect of the above figures is the large number of visits made during 1967 to estates in the Terai. This is a big change, for a few years ago the demand from the Terai was extremely poor.

There has been a general increase in contact with the Proprietory owned estates who normally seek general advice and guidance on day to day problems; this contrasts with the general pattern for Agency House managed estates whose requests for advice tend to be on specific problems.

By and large it was found that action was taken on the advice given and there is nothing more satisfying for an Advisory Officer to find that his advice has been taken and his efforts have been worthwhile. It has been found on a few occasions that advice has been given in good faith, but this has been based on incorrect information furnished by the Manager. Advice based on incorrect information cannot result in benefit to the Manager and is a waste of the Advisory Officer's time. When advice is required on a problem, accurate details of all aspects of the problem must be given.

In general all the districts had a good season and while the excellent weather must receive most of the credit for this, we would like to think that the efforts of the Advisory Officers helped in some small way. The principal points arising from advisory work during the year are discussed briefly below.

(**a**) **Drainage :** This topic occpuies a great deal of the Advisory Officers' time on the plains gardens and estates are becoming more conscious of the need for a proper and systematic system of drains. Advice on this big problem cannot be based on sound scientific backing for there is a distinct lack of basic information on the various factors attached to drainage problems and as such all the recommendation are *ad hoc*. It is worth recording the fact that many estates still drain replanted and extension areas one or two years *after* planting. This method is not satisfactory and a good system of drains can only be achieved by planning and digging the drains prior to planting in extension areas and before planting the rehabilitation crop in replanted areas.

(**b**) **Pruning Cycles :** Considerable interest has been shown on plains estates over the longer pruning cycles and more estates are introducing one or other of the heavier skiffs. In Darjeeling there is also a tendency to prune at less frequent intervals and this has resulted in an increase in the valuable first and second flush crop. An essential adjunct to an increase in the length of the pruning cycle in Darjeeling is the maintenance of a strict seven day plucking round, and on occasions gardens that have introduced a longer pruning cycle have been unable to harvest the extra crop.

(**c**) **Plucking :** By and large this aspect of tea culture does not cause any headaches to the Advisory Officer on the plains, for most estates man-

age to harvest their leaf on a fairly regular round and bring to the factory a standard of leaf suitable to the type of tea commonly made. In Darjeeling, however, this is not the case and time and again it is seen that leaf is not harvested when ready, with the result that there is an unnecessary rise in the plucking table and the resultant loss in crop. There is no doubt that on many estates in Darjeeling a very significant increase in crop could be obtained by plucking on a regular seven day round. The Advisory Officer in Darjeeling is frequently greeted with the question, "it is essential I increase my crop, how should this be done?" The answer, on a large number of occasions, is simply, "plucking on a regular round". This very frequently receives the reply, "I can't, due to insufficient labour" There is no way out of the fact that when an increase in crop is desired then the necessary facilities to harvest the leaf must be made before that increase can be obtained.

(**d**) **Shade :** The establishment and maintenance of a permanent stand of shade is causing a great deal of concern in most plains estates. Advice has been given to stop using the common species *Albizzia odoratissima* mainly due to its extreme susceptibility to all kinds of pests. A fairly new introduction, namely, *Acacia lenticularis* has grown well in all districts and is at present fairly pest and disease free. There is a tendency not to give shade the necessary care and attention required during the establishment period and although establishment is not easy, a little extra care in the early stages would lessen the difficulties.

(**e**) **Vegetative Propagation :** Routine advice on nurseries, multiplication plots etc. occupied a fair amount of the Advisory Officers time. Advice on these topics are generally confined to estates who have recently started on V.P. work. Generally, estates that have been doing V.P. work for sometime, have mastered the technique in the nursery and advice on these estates is confined to the field. There is still a distinct lack of appreciation that "Clones are Different' and a regular question is, "What yield can I expect from such and such a clone?" This sort of question cannot be answered by the Advisory Officers and it is up to estates to plant up their own Agricultural Trials with the sole object of finding out which clones suit their estates. There is no doubt that young clonal plants are not as hardy as young seedling plants and this is not often appreciated for small plants in small pits are often planted which results in a high mortality rate. Under these circumstances the clone is often accused of being unsuitable. Tocklai clones 19/29/13 and 106/1 are the most widely planted clones and appear to do well under most conditions where soil and drainage are satisfactory; 19/29/13 is susceptible to all mites and *Helopeltis* damage.

In Darjeeling there has been an increase in the interest shown in clonal work which may be due partly to the setting up of the Clonal Proving Station. However, except for a few estates, clonal work in Darjeeling is still very

much in its infancy. It is interesting to record that tests done on 19/29, 13 growing at mid elevation have shown that it has flavour better than the hybrid *jat* standard and this therefore suggests that this clone could be used with advantage in a replanting programme in Darjeeling.

(**f**) **Extensions, Uprooting and Replanting :** Following the occurrence of widespread unlawful encroachment of land, mainly in the Terai, the rate of extending has increased in that area. Dooars estates having suitable land for extension, are using this land prior to uprooting. In Darjeeling very little suitable land for extension is available. Most estates on the plains are following some sort of extension, uprooting and replanting programme.

Where replanting is being done following uprooting, rarely is an adequate period of rehabilitation given and this is clearly seen in the poor results obtained in many of the recently replanted areas. These areas are a continual source of worry to Advisory Officers, and there is little that can be done once the area has been replanted. The only sure way of ensuring the success of a replanted area is to deep plough and sub soil to the deepest possible depth the equipment will allow immediately after uprooting. Drains must be dug at this time and then a two years rest under a heavy cover crop should be given.

Under this heading it must be mentioned that in spite of continued advice on the unsuitability of light leaf *jat* for planting in the Dooars and Terai, estates still insist on using them, and it is areas replanted with these *jat* that cause the most concern.

Replanting in Darjeeling is mainly confined to those estates that are in a good financial position and have proved clonal material available. There is no known suitable seed stock freely available for Darjeeling at present but encouraging results have been had from a new biclonal cross developed by Tocklai. Plots of this cross have been established on a Darjeeling estate and to date the progeny have given excellent flavour and are more vigorous than the common hybrid tea.

(**g**) **Pests & Diseases :** Member estates in the Dooars and Terai received regular advice on Pests and Diseases control throughout the year by the circulation of the monthly "Pests & Diseases Bulletin". This provide a most popular document and definitely helped estates to take adequate steps in advance. In Darjeeling the Advisory Officer spends a great deal of his time advising on the control of pests and diseases. He reports that the incidence of mites was less in 1967 due to more timely application of

pesticides and this indicates that his advice has been followed and has paid. In Darjeeling pests eating the roots i.e. Gerambycid borers and Cockchafer grubs are causing concern and this problem has been referred to the Entomological Department.

(b) **Cultivation & Weed Control :** Much more interest has been shown in the possibility of using chemicals for weed control and it is hoped that this interest will not wane due to the difficulties being experienced over obtaining some of the imported chemicals, particularly Gramoxone. Estates which have laid out trials using chemicals are more often than not convinced that chemical weed control is here to stay if only the supply of chemicals could be guaranteed.

YIELD SURVEY

As mentioned at the beginning of this report, Dr. N. B. Chanda has been collecting yield and field management data from Member estates. He has completed the survey for 34 estates. Brief details are that yield figures for the 15 years ending 1966 for each section are being tabulated along with management practices and rainfall data. The object of the survey is to find out the factors that lead to an increase or decrease in yield and the magnitude of the increase or decrease. The mass of data will have to be analysed before any conclusions can be reached and it is hoped that these conclusions will form a very useful guide for advisory recommendations and planning of future experiments.

While firm conclusions will have to wait until an analysis is complete, it is interesting to record some observations already made.

(a) **Yield Increase & N. fertilizers :** The average increase in overall yield of the gardens surveyed is only 290 kg/ha during the 15 year period. The lowest increase was 60 kg/ha and the highest 610 kg/ha. This is in spite of an increase during the periods in the use of inorganic nitrogen from nil on some estates to between 90 to 112 kg N/ha.

(b) **Replanted Tea :** By and large the yield of replanted areas is disappointing and is only a little above the yield prior to replanting.

(c) **Jats :** Only a few estates are using clones and most of the replanting has been done with light leafed *jats*.

(d) **Rehabilitation :** Nearly all replanting was done within 8-10 months of uprooting and on some estates, replanting was done 3-4 months

after uprooting. Only a few estates had rehabilitation periods longer than one year and not one estate of those so far surveyed, used, a subsoiler between uprooting and replanting.

(**e**) **Records :** By and large the records kept by the estates were satisfactory except for details of cultivation and vacancy counts.

MEETINGS

The Chief advisory Officer, West Bengal paid three visits to Tocklai and the other Advisory Officers and Dr. Chanda two visits each.

The following annual general meetings were attended :-

Terai Branch of Indian Tea Association by Chief Advisory Officer, West-Bengal.
Dooars Branch of Indian Tea Association by Chief Advisory Officer, and Advisory Officer, Dooars.
Darjeeling Branch of Indian Tea Association by Chief Advisory Officer and Advisory Officer, Darjeeling.
Tea Association of India, North Bengal Branch by Advisory Officer, Dooars & Advisory Officer, Darjeeing & Terai.

There are three Area Scientific Committees in West Bengal, one in each District. The Advisory Officer, Darjeeling is Secretary for the Darjeeling ad Terai Committees and the Advisory Officer, Dooars is Secretary for the Dooars Committee The Chief Advisory Officer, West Bengal is an ex-officio member of all these committees.

During the year there were a total of 11 meetings: the Dooars committee met 3 times and the other two 4 times each Whenever possible meetings were held to coincide with visits to Bengal of officers from Tocklai. There was always a free exchange of ideas and all meetings have proved extremely helpful and have improved the liaison between the planter and the scientific staff.

EXPERIMENTS

Experiments & other work at Nagrakata Head Quarters

Two blocks of an agricultural trial on clones were planted. 15 Toklai clones, 2 new clones from Mal and a *jat* standard are being tested in this trial.

A trial on cleft grafting was carried out in the Jiti seed bari. The main object was to see if cleft grafting using the same methods as practiced in Malawi would be successful in the Dooars. Briefly the results have shown

that cleft grafting is successful and there is seasonal variation in success. The cold weather months October to February appear to be the best months for grafting with another peak success in June and July. The trial is being continued to see if the same trend will be experienced in 1968.

A small trial on the effect on soil pH following application of Sulphate of ammonia was laid out at Nagrakata.

Observation and multiplication plots of clones selected for further trial from Mal were established and to date three appear to have promise.

Nearly 46,000 cuttings of Tocklai release clones were issued to Member estates in West Bengal. This shows an increase in the demand over last year, but this is mainly due to the inclusion of two new clones. It is felt that many more estates could make use of the clonal material available at Nagrakata, for instance of the 178 Members in West Bengal only 49 indented for cuttings of the new releases, TV 14 and TV 15.

Clonal Proving Station : Darjeeling

The first trial at the Clonal Proving Station was planted. The trial consists of 14 clones from estates, 3 from Mal, 2 Tocklai release clones and one biclonal seed.

Field Experiments on Gardens

50 short and long term experiments were in progress on Member estates on cultivation, shade, manuring, pruning, plucking, rehabilitation of soil, irrigation, clonal seed, reclamation of subacid soils and pests and diseases control. A complete list of Advisory Department Experiments appears in Appendix A, and a list of experiments being conducted in co-operation with other branches is given in Appendix B The Chief Advisory Office West Bengal paid 116 visits to these experiments.

MISCELLANEOUS

Soil Testing : A total of 3224 soil samples were analysed during the year and of these 518 were for experiments.

Visitors : A large number of visitors visited the Headquarters during the year and we were particularly pleased to welcome, Dr. R. T. Ellis, Director, Tea Research Foundation Central Africa and Dr. L. H. Fernando, Assistant Director, T.R.I., Ceylon. They were both shown estates in the Dooars and Darjeeling during their brief visits.

Building and Land : A bungalow for the Advisory Officer, Dooars was completed and three staff quarters at Nagrakata were built. Approximately 20 acres of land which was acquired from Bhogotpore T.E. was fenced and part of this land was prepared for planting.

Meteorological Stations : Two fully equipped Meteorological Stations are maintained in West Bengal; one at Nagrakata H. Q. and the other at Nagri Farm T. E. in Darjeeling. Regular readings were kept throughout the year.

SUMMARY OF RESULTS

ADVISORY DEPARTMENT FIELD EXPERIMENTS

Brief summaries, as at the first of April 1968, of some of the experiments conducted by the Department on Member estates are given below :

Irrigation

North Bank, Assam

In two experiments (Expts. No. AN 55 and AN 61) irrigation failed to give higher total crop than no irrigation but it tended to increase the early season crop. An attempt was made to find out the economics of irrigation, taking the cost of irrigation at Rs.35/- per 25 mm equivalent of rain per hectare, and the arbitrary profit return at Re 1/-, Rs.2/- and Rs.3/- per kg. of made tea. None of the treatments, which ranged from a total of 75 mm to 426 mm equivalent of rain applied over a period of 3 to 5 months during the dry weather were found to be economic on these calculations.

Dooars, West Bengal

In one experiment (Expt. No. D. 31), light skiffed mature tea responded very well to irrigation as can be seen in Table 1

Table 1. Yield of made tea in kg/ha and economics of irrigation.

Treatments	Irrigation in mm (Total)	Yield	Cost of irrigation at Rs. 35/- per 25 mm per hectare (in rupees)	Net profit or loss over no irrigation (Control) on the basis of profit returns of Re 1/-, Rs. 2/- and Rs. 3/- per kg of made tea		
				Re 1/-	Rs. 2/-	Rs. 3/-
No irrigation (Control)	- -	1920	- -	—	—	—
25 mm per month (Jan., Feb., Mar. & April)	100	2216	140.00	+ 156.00	+452.00	+748.00
37.5 mm per month (Jan., Feb., Mar. & April)	150	2204	210.00	+ 74.00	+358.00	+642.00
50 mm per month (Jan., Feb., Mar. & April	200	2291	280.00	+ 91.00	+462.00	+833.00
L. S. D. (P = .05)	-	256		—	—	—
C. V. %	-	7.7	—	—	—	-

Nitrogenous Fertilisers

1) **High frequency application of sulphate of ammonia :** Several experiments were in progress to study and compare the effects of single and high frequency applications of different levels of nitrogen (N) on the yield of tea. The levels of nitrogen varied from 100 kg to 250 kg/ha, applied in a single dose or in 4 to 8 equal monthly doses. Results of some experiments are described below.

South Bank, Assam

In three experiments (Expts. No. AS 62, AS 64 and AS 71) levels higher than 100 kg and 112 kg nitrogen per hectare did not bring about any significant improvement in yield whether these quantities were applied in one dose or 4 to 8 doses. The tea was medium skiffed in Expt. Nos. AS 64 and AS 71 and pruned in Expt. No. AS 62.

In another experiment (Expt. No. AS 56), where the nitrogen rates were applied in single doses, 157 kg nitrogen per hectare was significantly better than 112 kg N ha and 247 kg N ha. The tea was pruned in the 1966-67 cold weather. As regards the high frequency applications, 112 kg N ha applied in 4 equal monthly doses gave significantly higher yield, and was more economical than the same amount of nitrogen applied in one dose.

The most economical treatment in this experiment (Expt. No. AS 56) was 157 kg N ha applied in one dose. This was true whether the profit return was Re 1/-, Rs. 2/- or Rs. 3/- per kg of made tea (Table 2).

Table 2. Yield of made tea in kg per hectare and economics of manuring

Treatments	Yield	Cost of fertilizer in rupees	Cost of application @ Rs. 12.50 per application per hectare	Total cost in rupees	Net profit or loss over T_1 (Control) on the basis of profit return of Re 1/-, Rs. 2/- and Rs.3/- per kg of made tea.		
					Rs.1.00	Rs.2.00	Rs.3.00
T_1 — 112 kg N/ha, one dose (Control)	2002	209.44	12.50	221.94	—	—	—
T_2 — 157 kg N/ha, „ „	2317	293.59	12.50	306.09	230.85	545.85	860.85
T_3 — 202 kg N/ha, „ „	2215	377.74	12.50	390.24	44.70	257.70	470.70
T_4 — 247 kg N/ha, „ „	2088	461.89	12.50	474.39	−166.45	80.45	5.55
T_5 — 28 × 4 doses 112 kg N/ha	2206	209.44	50.00	259.44	166.50	370.50	574.50
T_6 — 31.4 × 5 „ — 157 kg N/ha	2292	293.59	62.50	356.09	155.85	445.85	735.85
T_7 — 33.7 × 6 „ = 202 kg N/ha	2432	377.74	75.00	452.74	99.20	429.20	759.20
T_8 — 30.9 × 8 „ 247 kg N/ha	2221	461.89	100.00	561.89	−120.95	98.05	317.05
L. S. D. (P=.05 (P=.01	163 222						
C. V. %	5.0						

North Bank, Assam

In Experiment No. AN 59, the results were the same as Experiment Nos. AS 62, AS 64 and AS 71. The tea was deep skiffed.

Cachar, Assam

In one experiment (Expt. No. C 29), where the tea was unpruned, the results were the same as the North Bank experiment.

2) Placement of fertilisers :

Darjeeling, West Bengal

In one experiment (Expt. No. Dj. 29), placement of fertiliser in a trench 5 cm wide and 2.5 cm deep and then covered with soil, made no difference to yield when compared with the traditional method of applying fertiliser on the surface soil as half bangles.

N. P. K. Manuring

South Bank, Assam

In one experiment (Expt. No. AS 44) which was started in 1965 in a section of 10 years old replanted tea, a high level of phosphate and potash (each at 224 kg/ha) in conjunction with 112 kg N/ha gave higher yield than 112 kg N/ha in 1965 and 1966. In 1967, phosphate and potash applications were discontinued but even then, the yield was higher than 112 kg N/ha indicating thereby that the residual effects of P and K were significantly beneficial. (table 3).

Table 3 Yield of made tea in kg/ha

Treatments	N – P_2O_5 – K_2O / Year	1965	1966	1967	Total
	112-0-0	1652	1297	1513	4462
In 1965 and 1966 In 1967	112-224-224 / 112-0-0	1808	1571	1788	5167
L.S.D.	P .05	75	126	150	—
	P .01	102	172	205	—
C.V.%		3.6	7.1	7.9	—

Economics of manuring on the basis of three years' data only, show the N.P.K. treatment to be economical providing the profit return was Rs. 2/- or more per kg of made tea, as can be seen in table 4.

Table 1 Economics of manuring

Treatments $N - P_2O_5 - K_2O$	Total yield of made teas in kg/ha for 3 years	Total cost of fertilizer per hectare for 3 years (in rupees)	Net profit or loss in rupees per year per hectare when the profit returns per kilo of tea are :		
			Re 1/-	Rs. 2/-	Rs. 3/-
112 - 0 - 0	4462	628.32	—	—	—
112 224 224 (P & K in 1965 & 1966 only ; in 1967 112 - 0 0	5167	1949.92	—205.53	29.47	264.47

Liming

South Bank, Assam

In one experiment (Expt. No. AS 78), liming at one tonne and two tonnes per hectare in conjunction with 100 kg nitrogen per hectare made no difference to the yield when compared with 100 kg N ha alone.

Pruning

Dooars, West Bengal

In 1967, Experiment No. D.2 had been in progress for thirteen years. The results confirmed that biennial pruning cycles gave more yield than annual pruning cycles. Whilst most of the increase in yield were obtained in the skiffed years, some increases were obtained in the pruned years also, especially in case of the prune, deep skiff cycle. Mean yields in the skiffed years once again confirmed that the lighter the skiff, the more the yield.

Among the three biennial cycles tried, the least fluctuation in yield between prunned and skiffed years took place in the prune deep skiff cycle.

As regards seasonal crop distribution, skiffing whether light, medium or deep, not only gave more early season crop which was expected but also more main and backend crop than annual pruning. The differentials, however, narrowed down considerably as the season progressed.

Cachar, Assam

In one experiment (Expt. No. C. 21), five years' data (1963-67) indicated that December was the most suitable month for light skiffing in a prune light skiff biennial cycle.

Six years' results of a pruning cycle experiment (Expt. No. C. 21) showed that pruning on 2 or 3 year old wood (i.e. when tea was pruned following one or two skiffed years) did not result in a loss of crop when compared with pruning on 1 year old wood (i.e. annual pruning). All types of skiff i. e. light, medium and deep gave higher yield than prune.

AGRICULTURE DEPARTMENT

Introduction

The main emphasis of the year's work lay in exploring the possibilities of obtaining big gains in crop yield and on certain other fundamental agronomic problems. The routine array of long and short term field experiments were carried on. Due to lack of land at Borbhetta some desirable and important experiments could not be laid out and the prospects for the future do not seem too bright in this respect.

During the year the range of subjects under study and experimentation included rehabilitation of land, grasses and legumes, clonal work, planting and spacing, shade, shade and manuring, N. P. K. manuring, nitrogenous and non-nitrogenous fertilizers, pruning, plucking and irrigation. Assistance, as required, was given to the Advisory Department Experiments.

RESEARCH AND EXPERIMENT

Rehabilitation of Land

One experiment at Borbhetta B 11 3 and two large scale experiments at Hunwal Tea Estate were started in 1966 to study the effects on rehabilitation of uprooted tea soils by using different species of grasses and green manure crops. The final results will not be available for a few years more because some treatments include longer rehabilitation periods than are at present in vogue.

An experiment B 6.3 started in 1962, showed definitely increased subsequent crop yields by keeping uprooted tea soil under natural fallow for two years before replanting, even without deep ploughing, green cropping or applying organic manure, when compared with fallow for only one year under the same conditions. Green cropping further improved yields. The experiment also showed that oilcake supplying 100 kg N ha was as effective in increasing tea yields as green cropping for one year.

At Borbhetta the following grasses are growing well in museum plots and showing promise from the Agronomists' view point, for rehabilitation purposes: *Crysopogon gryllus*, *Digitaria decumbens* (Pangola grass), *Digitaria eriantha* (Crab grass), *Eragrostis curvula* (Weeping love grass), *Eragrostis trichobes*, *Panicum maximum* (Guinea grass), *Pennisetum purpureum* (Nepier grass), *Pusa Giant Hybrid Napier*, *Tripsacum laxum* (Guatemala grass).

Some promising species were released to the industry during the year.

Shallow rooted grasses, when grown for rehabilitation, are usually covered by broadleaved weeds in the early stages of establishment but the weeds can be controlled by the application of 2,4-D at 2.5 kg ha.

Clonal Work

In 1967, two new clones TV 14 and TV 15 were released and cuttings were supplied to the industry.

A trial was laid out to study the possibility of raising cuttings speedily under transparent polythelene tents. The temperature and light within the tents were controlled by shading with coir mat netting on 1.8 metre high frames and kept moist with water sprinklers. The overhead matting was of one cm mesh. Sprinklers were fitted over the mats at four metres apart and were connected directly to an overhead water tank. They were turned on for one minute every six hours.

Cuttings were planted in the third week of October with either one or two cuttings in each tube (20 cm long and 17 cm lay flat). The tubes were aranged in strips each containing 10 tubes by 50 tubes. Polythelene sheets of 1.8 metre width and 250 gauge were stretched over a half moon shaped frames constructed with curved bamboo laths. The polythelene sheet was tucked into the ground on all four sides, so that the tent was sealed to the outside atmosphere.

In the control treatments a polythelene sheet was laid at the top of the bamboo frame but the sides were kept open so that the outside atmosphere could circulate.

Results showed that the cuttings kept under the sealed tent for 12 weeks made faster growth than in the control treatments. On average the tented cuttings reached a height of 25 cm with a nearly 100 per cent survival and they were ready for transplantation after six months. To keep down the weed growth in the tubes under the tents, Simazine at the rate of one kg ha was applied as pre-emergent.

Blackening of the stems of cuttings before rooting, at times is a problem of vegetative propagation. Observations indicated that the blackening often takes place on the side of the cutting stem opposite the petiole and that sometimes it starts at the pointed end of the stem.

A trial was laid out in beds under bamboo lath frames to verify these observations and also to find out if soaking of the cuttings in water before planting or drenching the beds after planting may cause blackening. The

bottom cuts of the cuttings were made in three ways: at the same angle with the leaf petiole, at the opposite angle to the petiole and at right angles to the stem. Antibiotic, Streptomycin at 10 I. U./ml, was applied to one treatment. Observations taken after eight weeks showed that only 2.6 per cent of the cuttings developed blackening which started from the pointed end and that the antibiotic was of no help. The most interesting result was that blackening developed mostly (16%) on the southern side of the stem, and was the least (1.6%) on the northern side; no matter how the cuts on the stem-ends were oriented.

Planting and Spacing

The results of the experiment (B 104) using five spacings, two *jats* of tea and three levels of nitrogen were published in 1966. During 1967, the plots under wider spacing (120 cm × 120 cm) were still lagging behind as compared to closer spacings. The different levels of nitrogen (90, 135, 180 kg ha) and their interplay with spacings were not significant.

In one experiment (B 8.1) two clones, 100/1 and 19/29/13, were planted in October 1966 with four spacings using plant population densities ranging from 9,260 to 37,000 per hectare with three levels of nitrogen (100, 200 and 300 kg N/ha). The area was mulched with thatch and jungle and mulching had beneficial effects on controlling weeds, conserving moisture and reducing deaths.

In another experiment (B 8.2) Khoijan *jat* of tea was planted at six spacings with populations varying from 6,900 to 18,500 per hectare. The 18,500 plots were planted at (120 cm × 90 cm) with two plants in a hole (doubleton). When two plants were put together virtually no infilling had to be done during the first two years because at least one of the two plants survived. The first frame-formative prune was given to these plants by treating them as though they were a single plant and so far these plants have produced better frames than single plants. The doubletons have now come to a stage when they are going to fuse into one another. This will be an economical proposition where enough clonal material for propagation is available, because raising two cuttings in one sleeve involves only slight extra cost which will make establishment of clonal tea easier and economical.

Shade and Manuring

Two experiments (B 1.A.1 and B 1.A.2) on shade tree species are merely screening experiments. Observations taken so far indicate that the following species, besides *Albizzia odoratissima*, *A. lebbek* and *A. procera*, are good

growers at Borbhetta and producing moderate shade: *Albizzia julibrisin, A. gambleii, A. nemo, A. zygia, Acacia lenticularis, Dalbergia sericea* and *Piptadenia falcata*

Manuring

In one experiment (B 20.1) different combinations of P and K mixtures (0, 45, 90, 180 kg/ha nutrient) with a standard dressing of 90 kg N/ha were tried on tea which was medium pruned in December 1966 and manured in April 1967. The results are given in table 1.

Table 1. Yield of made tea in kg per hectare in 1967 adjusted by covariance on existing number of bushes.

P_2O_5 \ K_2O	K_0	K_{45}	K_{90}	K_{180}	Mean
P_0	485	672	494	477	532
P_{45}	529	468	520	555	518
P_{90}	494	576	563	472	526
P_{180}	481	555	477	524	509
Mean	497	568	513	507	

L. S. D. at P 0.05 for P_2O_5 & K_2O interaction 112

C. V. % 15.0

The results showed significant differences between combinations of P and K levels P_0 K_{45} produced significantly higher yields than all other combinations except P_{90} K_{45} and P_{90} K_{90}

The previous results of experiment B 7 and B 9.2 together with the results of this experiment show that the N. P. K. mixtures with N_{90} and P and K less than 180 each are equally beneficial as N_{90} P_{180} K_{180} It is therefore concluded that N_{90} P_{90} K_{90} can replace without detriment, the N_{90} P_{180} K_{180} mixture previously recommended for medium pruned tea.

An experiment B 43 C 1 on placement of phosphatic fertilizer was started in 1966 on unshaded Betjan *jat* of tea planted in 1959. Single superphosphate was tried both as broadcast and in placement. Since 1963 no P and K has been applied to the tea. The treatments and the results are given in Table 2.

Table 2. Yield of made tea in kg/ha according to phosphate rates and method of application.

Treatments	Yield
No superphosphate	1578
Superphosphate @20 kg P_2O_5 /ha – Broadcast	1700
Superphosphate @20 kg P_2O_5 /ha – Placed 10 cm deep	1546
Superphosphate @20 kg P_2O_5 /ha– Placed 20 cm deep	1602
Superphosphate @20 kg P_2O_5 /ha– Placed 30 cm deep	1584
L. S. D.	N. S.
C. V.%	7.5

The results show that under the condition of this experiment there is no advantage from using single superphosphate on the yield of tea, whether broadcast or placed at different depths in the soil.

A comparison of the efficiency of rockphosphate with superphosphate on the growth of green crop, *Crotalaria anagyroides*, B 43 D. 2, confirmed that superphosphate at the rate of 1 kg per 25 running metres was significantly more efficient than rockphosphate applied even at the highest rate of 3 kg per 25 running metres when drilled in with the green crop.

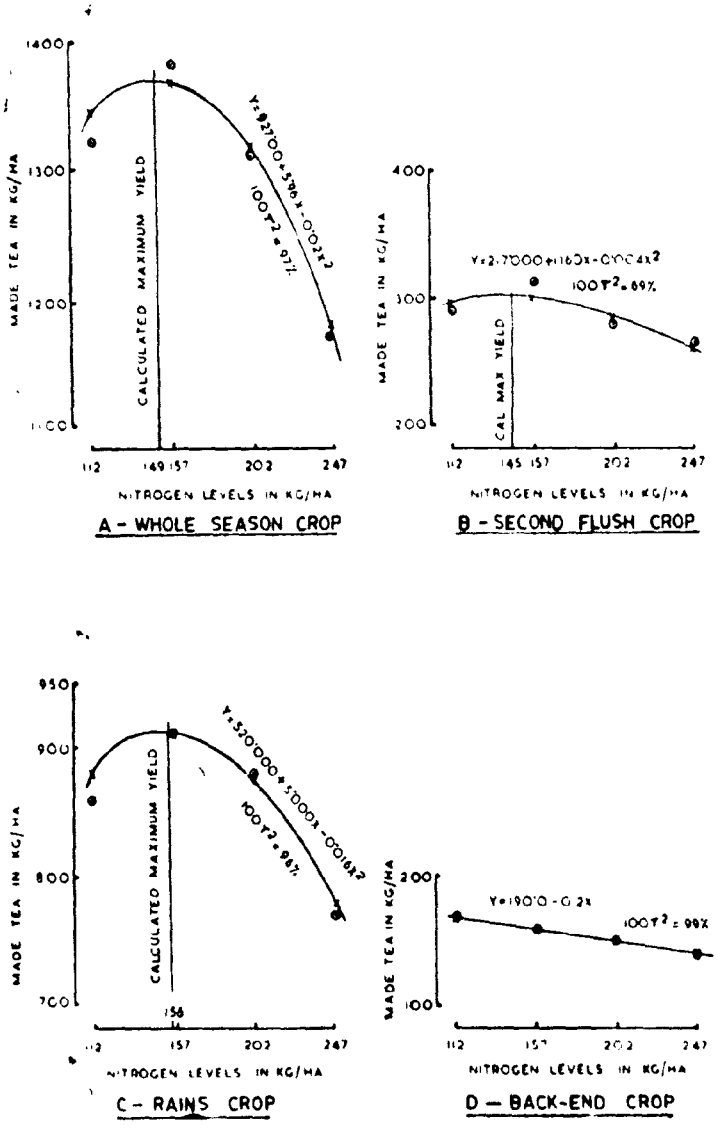
When application of 25 gm of superphosphate was compared with 25 gm, 50 gm and 75 gm of rockphosphate in the planting mixture for tea there was no significant difference in the growth of the plants during the first six months.

Two experiments on divided doses of sulphate of ammonia are in progress. Both of the experiments have shown that there was no benefit in crop yield when nitrogen was applied between 90 kg and 135 kg per hectare in two or more divided doses in comparison with single whole applications.

It was interesting to note that when mean yield responses for 1966 and 1967 for 112, 157, 202 and 247 kg nitrogen were plotted on graphs, calculated from regression equations for the whole season, 2nd flush, main

and back end crop, the optimum level of nitrogen for the whole season crop was 149 kg N/ha (Fig.1). It can also be said that levels of nitrogen higher than 157 kg N/ha tend to depress yield mainly in the rains. In other words it appears that the critical limit of nitrogen is associated with the rains crop.

FIG. 1 SEASONAL DISTRIBUTION OF CROP : YIELD OF MADE TEA IN KG/HA (AVERAGE OF 1966 & 1967)



An undue reduction of soil acidity by continued applications of sulphate of ammonia could affect yields adversely. An experiment (B 41.2) was therefore started in 1967 to study the effect of lime alone and in combination with sulphate of ammonia on the soil acidity and yield of tea on a Burma *jat* of tea planted in 1922. The nine treatment combinations were obtained by using three levels of nitrogen as sulphate of ammonia (0,100 and 200 kg/ha) and three levels of lime (0,1.2 tonne ha). The results for the first year are given in Table 3.

Table 3. Yield of made tea in kg ha during 1967

Slaked lime / S. O. A.	L_0	L_1	L_2	Mean	% increase
N_0	827	912	920	886	—
N_{100}	929	1006	989	974	9.9
N_{200}	937	1108	920	988	11.5
Mean	898	1009	943		
% increase		12.4	5.0		

L. S. D at P = 0.05 for treatment means = 81
L. S. D. at P = 0.05 for L × N interaction = 141
C. V. % .. = 8.6

The results show significant differences between both lime and nitrogen levels as well as between treatment combinations. It can be seen that 1 tonne/ha of lime significantly increased by 12.4% yields over no lime. However the higher levels (2 tonne ha) of lime failed to give any significant increase over no lime. Further, the overall effect of both the nitrogen levels at 100 and 200 kg/ha produced significant increases over no nitrogen, there being no significant difference between the two levels. Among the combinations, N_{200} L_1, N_{100} L_1 and N_{100} L_2 gave significant increases over the control (N_0L_0), there being no significant differences between these three combinations themselves. It can be concluded that under the conditions of this 45 years old section at Borbhetta, previously manured continually with sulphate of ammonia, responses were obtained from 1 tonne of lime per hectare during the first year following application. Further studies are in progress.

In experiment (B 15/2) started in 1958, Urea was applied broadcast and also sprayed on the soil. The results were last reported in 1966. The experiment was modified in 1967 with some new treatments including forking-in of urea. The results show that when urea was forked in, it gave no added advantage in terms of yield. There was a suggestion that forking may have depressed yield and this may be due to the mechanical damage to the feeder roots by digging.

In comparing the effects of sulphate of ammonia and urea as a source of nitrogen in 100–20–40 N. P. K. mixtures for tea (B 108/1.1) it was found that the mixtures are equally efficient whether the nitrogen source is wholly sulphate of ammonia or half as urea and half as sulphate of ammonia. The mixture containing half the nitrogen as urea and the other half of nitrogen as sulphate of ammonia is cheaper than the one containing sulphate of ammonia only. Because urea is physically incompatible with single superphosphate, mainly due to absorption of water, the application has to be made within 24 hours of mixing. However it may be possible to supply the nitrogen requirements of N. P. K. mixtures with suitable proportions of urea and sulphate of ammonia so as to reduce the hazards of storing. It was found (B 19/67) that when 20 per cent N as urea, was mixed with superphosphate and immediately stored in sealed alkathene lined bags, there was no deterioration in the dryness of the mixture for four months. If the mixture can be sun dried before storing, the proportion of N as urea can be doubled.

From the second year's results on calcium ammonium nitrate used as a source of nitrogen (B 64/1.1) it can be said that calcium ammonium nitrate was as efficient as sulphate of ammonia at rates supplying 90 kg nitrogen (N) per hectare. However there are indications that the performance of calcium ammonium nitrate is still better if it is alternated with sulphate of ammonia as a source of nitrogen but the long term effects of using calcium ammonium nitrate are still to be studied.

In 1966 an experiment (B 34.1/7) was started to study the effects of pruning litter and mulch on a Burma *jat* of tea planted in 1920, annually pruned about 1 cm up and tipped at 20 cm. Yields are given in table 4.

Table 4. Yield of made tea in kg/ha during 1966 & 1967

Treatments	1966		1967		Mean percentage
	Yield	Per cent decrease from T_1	Yield	Per cent decrrase from T_1	
T_1– Prunings not removed	970	—	1007	—	100
T_2– Prunings removed	868	10.5	814	19.2	85
T_3– Prunings removed but mulch added	916	5.6	900	10.6	92
L.S.D. at P=0.05	63		90		
L.S.D. at P=0.01	—		128		
C.V%	5.3		7.7		

In the first year, removal of pruning from the soil caused a 10.5 per cent drop in yield and in the second year 19.2 per cent. It will be seen that mulch has to some extent counteracted the ill effects of removing prunings, but it is impossible to tell from the design of this experiment what the beneficial effects of the mulch are due to.

It was found that muriate of potash can be sprayed on plucked tea bushes using a hand operated sprayer between four per cent and eight per cent (W/W) concentrations without causing leaf scorch.

In another exploratory trial 90:20:40 mixtures of N. P. K. made up of urea or sulphate of ammonia, ammonium phosphate, muriate of potash or sulphate of potash were used in various concentrations four per cent to twentyfour per cent W/W) as foliar sprays on plucked tea.

The results showed that all combinations of N. P. K. mixture were safe up to 10 per cent W W using hand operated sprayers and up to 20 per cent W/W with low volume power sprayers, especially with mist sprayers of the Micronette type. Potassium sulphate was found to cause more scorch than muriate of potash.

Pruning and Plucking

An experiment (B 15/1.1) was modified in 1965 to include five different pruning cycles but the treatments can not be compared together until 1971. However the three year cycles viz, Prune—Medium skiff—Deep skiff and Prune-Deep skiff—Medium skiff, have so far showed no differences in yield between themselves.

The Tocklai Manual Plucking Aid was tried along with plucking shears received from a commercial concern. First results showed that both the aids reduced crop yield. However, the Tocklai Manual Aid was modified three times during the season and the latest model indicated improved performance but was available from August only. The commercial shears damaged 39 per cent coarse leaf as against nine per cent by the latest Tocklai Plucking Aid. As regards damage to tender shoots both machines performed equally (9.5 per cent and 10.5 per cent by the Tocklai Plucking Aid and the shears respectively).

The possibilities of chemical defoliants were considered under circumstances when defoliation of bushes in the cold weather has to be resorted to as a deterrent against red spider infestation. Although defoliation is no longer a Tocklai recommendation, some estates insist they have to do it for pest control. Gramoxone and Aretit were tried as chemical defoliants and both reduced crop. It was found that both the chemicals can defoliate upto 80 per cent of the leaves and at the same time they controlled the growth of mosses and lichens. Aretit was found to cause less die back (up to 50 per cent) than gramoxone. Defoliation whether by hand or by chemicals quickened bud break.

In the 1966 Annual Report a review of all the experiments on herbicides conducted was given. During the year the following gave promising results.

Linuron (Afalon) - as a pre-emergent weedicide it satisfactorily controlled broadleaved weeds and, with less effect, some grasses like *Paspalum conjugatum*, *Imperata cylindrica* and *Cyperus* sedge species. It was used in young tea areas without harm to tea. A first dose of 2 to 4 kg/ha followed by a second dose of 2 kg/ha after three months gave a good control.

Diuron (Karmex)- used as post emergent at 2 to 3 kg/ha controlled most of the broadleaved weeds and some grass species.

Amitrol (Weedazol, Bladex 'O') - used as a post emergent at 2 to 3 kg ha controlled mostly broad leaved weeds.

Prefix- used as post emergent was effective in controlling broadleaved weeds when applied at 3 to 4 kg/ha. Spray drift on tea caused some scorching of leaves.

NaTA- used in seed nursery as well as on young tea at 2 to 4 kg/ha as pre-emergent was very effective against fairly deep rooted grasses. Higher levels than 2 kg caused slightly deleterious effects on tea.

Tenoran and Cotoran- are chemical herbicides acting through roots. Both were applied as post-emergents in young tea areas and both were effective against broadleaved weeds and grasses without causing any deleterious effects on the tea when applied at the rate of 3 to 4 kg/ha followed by a second dose of 2 kg ha after about two months.

Borbhetta Field Experimental Estate Report

Labour - The average daily attendance of labour during the year compared with that of last six years was as follows :-

1961	337.18
1962	299.29
1963	253.31
1964 ...	229.00*
1965 ...	250.22
1966	247.57
1967	230.66

(lower attendance due to a strike)

Crop— The total yield of green leaf during the year compared with that of last six years was as follows : -

Year	Yield
1961	1,31,782 kg
1962	1,24,788 kg
1963	1,23,483 kg
1964	1,26,671 kg
1965	1,32,131 kg
1966	1,34,730 kg
1967	1,29,455 kg

Of the 1967 crop, 1,10,761 kg of green leaf was sold to the Jorehaut Tea Co., Ltd. and the remainder was used for experimental manufacture. General plucking was stopped on 30.11.67.

Vegetative Propagation— During the year a total of 1,07,003 pre-treated/fresh cuttings and 2015 clonal plants were supplied to T. R. A. Member gardens in Assam. 55,845 cuttings were issued by the West Bengal Advisory Department and 600 cuttings by the Cachar Advisory Department.

Fifty six rooted cuttings of three different shade tree species were distributed to some T. R. A. Member gardens during the year.

Land— Borbhetta Field Experimental Estate has been used for about 50 years for all kinds of experiments on fertilizers, application of lime and sulphur (in heavy doses), different methods and intensities of soil cultivation, shade and no shade etc. and as a result many areas at Borbhetta have become unreliable for future experimentation. There is no new land left at Borbhetta; and therefore obtaining an area of virgin land to conduct new field experiments has become an urgent necessity.

SOIL CHEMISTRY DEPARTMENT

Soil Survey

The object of the soil survey, method of soil sampling and of chemical and physical analyses are described in Tocklai Occasional Scientific Paper Number 1, which dealt with Jorhat area soils and was published in January, 1968. During the year the Dooars and Terai district soils were analysed and these results will be published in Tocklai Occasional Scientific Paper Number 2 which is now in the press. Important conclusions drawn from the results of the soil survey of the Dooars and Terai district soils are :

(i) Texturally, Eastern Dooars soils are silty clay loams, whereas Western Dooars and Terai soils are coarse sandy loams.

(ii) In spite of these differences, deterioration of soil structure continues up to 20 years and probably more, but the soil aggregate status thereafter under old tea, tends to improve. In general, effects of these deterioration and regeneration processes are maximum in the case of aggregates at and over 1 mm in size.

(iii) Progressive increases are well marked in soil acidity and lime requirement values with the age of cropping. In accordance with theoretical expectations, the rate of increase has been found to be maximum during the initial ten year period of cropping. In agreement with the change in soil acidity, base saturation status also progressively decreases with the age of cropping. Estimates of the *readily available* basic nutrients such as calcium, magnesium and potassium, indicate that leaching loss of all these nutrients, especially during the first 20 years of cropping from virgin jungle, has caused the decrease in base saturation.

(iv) The presence of free calcium and magnesium salts in the Dooars and Terai soils is marked. Loss of calcium and magnesium due to leaching over a 40 years cropping period has been found to be large. Contrary to the loss of calcium, which is confined only to the *readily available* portion, magnesium loss is largely accounted for by the decrease of the *non-readily available* reserve mineral portion of the soils.

(v) An appreciable and progressive decrease has been noted in nitrogen and organic matter contents of soils with the age of cropping: the rate of decrease being maximum during the early years from virgin jungle.

(vi) *Total* and *available* phosphate contents also decrease with increasing age of cropping, the maximum rate being during the first 20 years or so from virgin jungle.

Thus, it appears that appreciable deterioration in organic matter, nutrients and soil structure takes place approximately during the first 20 year period of cropping. During this period, soil acidity and lime requirement increase. These trends of depletion in soil fertility status are in close agreement with the declining yield trend observed at Borbhetta after 20 to 25 years from planting irrespective of different manurial treatments (nitrogen alone at different levels and different N. P. K. mixtures) or various management practices (see Senior Agriculturist's paper "Agronomic progress and problems of the tea industry", presented at the Twentythird Tocklai Conference in November, 1967).

A comparison between Jorhat district soils and the Dooars-Terai soils, reveals some interesting points :

(i) The Dooars and Terai soils, in their upper layers (0-60 cm), have higher levels of organic carbon and nitrogen contents compared to soils of the Jorhat district. Comparative data are given in Table 1

Table 1

Nitrogen and organic carbon contents of Dooars and Terai, and Jorhat soils

Depth of sampling, cm	Per cent organic carbon content (on dry weight basis)				Per cent total nitrogen content (on dry weight basis)			
	Dooars & Terai		Jorhat		Dooars & Terai		Jorhat	
	Virgin	Old	Virgin	Old	Virgin	Old	Virgin	Old
0—30	2.32	1.39	0.83	0.68	0.194	0.143	0.099	0.07[illegible]
30—60	1.29	0.70	0.63	0.49	0.117	0.082	0.073	0.06[illegible]
60—90	0.71	0.36	0.55	0.41	0.063	0.041	0.062	0.052

From the table it is seen that the loss of organic carbon content over the 40 year cropping period is far more in the Dooars and Terai than in the Jorhat district. The loss in the 0-30 cm layer is roughly six times more. In spite of this heavy total loss, old tea soils of the Dooars and Terai up to 60 cm depth (2 ft.) have levels of organic carbon which are either higher or equal to the Jorhat district virgin soils

The loss of nitrogen over the 40 year cropping period is also more in the Dooars and Terai than in the Jorhat district. As pointed out in the case of organic carbon, in spite of the higher amount of depletion of soil

nitrogen at Dooars and Terai, old tea soils up to 60 cm depth (2 ft.) have levels of total nitrogen which are either higher or equal to the Jorhat district virgin soils.

(ii) The Dooars and Terai soils have higher levels of the basic mineral reserves calcium, magnesium and potassium, compared with the Jorhat soils. This characteristic together with low silica sesquioxide ratio of the Dooars and Terai soils, indicates that the soils are formed from different rocks compared to the Jorhat soils. Comparative data are given in Table 2.

Table 2 :

Total calcium (Ca), magnesium (Mg), potash (K_2O) contents and silica-sesquioxide ratios of Dooars, Terai and Jorhat soils.

Depth of sampling, cm	Dooars and Terai				Jorhat			
	Silica-sesquioxide	Total calcium	Total-magnesium	Total potassium	Silica-sesquioxide	Total calcium	Total-magnesium	Total potassium
	Molar ratio	kg/ha	kg ha	kg/ha	Molar ratio	kg ha	kg ha	kg/ha
0—30	16.04	9,600	32,900	104,600	48 80	6,800	2,400	27,100
30—60	15.74	9,100	31,000	90,500	10 35	7,500	3,000	27,700
60—90	16.61	11,300	31,500	94,000	37 36	7,200	3,100	32,800

From table 2 it can be seen that the silica-sesquioxide ratio of the top 30 cm soils of the Dooars and Terai is approximately one-third of the Jorhat soils ratio. Also, the first 30 cm (1 ft. soils of the Dooars and Terai have roughly one and a half times more calcium content, fourteen times more magnesium and four times more potash than the Jorhat soils. Appreciable differences in the basic nutrient status and silica-sesquioxide ratio are also clearly seen in the subsoil layers, though in degree these are somewhat less compared to top 30 cm (1 ft.) soils. Besides the probable difference in parent materials from which the soils are formed, high amount of rainfall in the Dooars and Terai may also contribute towards the lower silica-sesquioxide ratios.

(iii) In comparison with the Jorhat virgin soils, the Dooars and Terai soils have roughly the same amount of *total* phosphate but fifteen times as much *available* phosphate Comparative data are given in Table 3.

Table 3 :

Changes of total and available phosphate (P_2O_5) contents of a 90 cm soil profile with varying periods of cropping in the Dooars, Terai and Jorhat districts

Age	Dooars and Terai		Jorhat	
	Total P_2O_5 (kg/ha)	Available P_2O_5 (kg/ha)	Total P_2O_5 (kg/ha)	Available P_2O_5 (kg/ha)
Virgin	6,700	230	5,000	20
Young	4,500	270	4,000	40
Medium	4,000	120	4,500	10
Old	3,800	110	5,000	15

From the table it is seen that the *available* phosphate contents of the cropped soils in the Dooars and Terai are roughly seven to ten times higher than the Jorhat soils. Moreover, with progressive cropping, phosphate is released from the *non-available* reserve sources (total) to the available pool in the Dooars and Terai, whereas at Jorhat the *non-available* stock of phosphate practically remains unchanged over the 40 year cropping period. Manuring according to our *old* recommendations has not stopped the depletion of available phosphate during the first 20 year cropping period regardless of area.

The effects of varying periods of cropping on the textural and structural characteristics of tea soils have been examined in thirteen tea districts which sampled the entire tea growing areas of North East India for the 1967/68 soil survey. It appears that these tea soils with the exception of Jorhat district, can be broadly classified under two main textural types, namely coarse sandy loams and silty clay loams. Jorhat district soils texturally vary between fine sandy loams and loams.

Soils of Darjeeling, Terai and Western Dooars; Mangaldoi and Bishnauth districts in the North Bank of Assam; Doom Dooma district in the South Bank of Assam and teela soils of Cachar are coarse sandy loams.

Soils of the Eastern and Central Dooars; Red Bank soils of Borsola and Bishnauth districts in the North Bank of Assam; Margherita, Dibrugarh, Nazira, Golaghat and Nowgong districts in the South Bank of Assam; flats and plateau soils of Cachar are silty clay loams.

The above regional classification on the basis of soil texture may ultimately be important for soil water management.

Silty clay loams have not shown appreciable changes in any of their mechanical fractions, coarse sand, fine sand, silt and clay with the varying age of cropping up to 40 years or more. Coarse sandy loams, however, indicate changes immediately after clear-felling the jungle and exposing the land under young tea. The coarse sand fraction decreases and the silt fraction increases and these changes are likely to be the effects of erosion. It is known that in the process of splash erosion, sand particles are more readily moved in splash than are finer soil particles. Further, when water moves, the finer particles tend to fill in the spaces around the remaining larger ones to form a relatively nonpervious layer. However, from young to old tea, over a period of 30 years or more, no more changes are observed in respect of the coarse sand and silt fractions.

In general, deterioration of the soil aggregates during the early years has been observed in the case of both textural soil types which increases to a maximum during the first 20 years of cropping. However, the loss of aggregates is later arrested and frequently an improvement can be noted under 40 year old tea, although no sample has yet been found which has shown recovery equal to virgin jungle.

It is also of interest to note that the loss of soil aggregates during the the first 10 to 20 years cropping period is practically the same for both the coarse sandy loams and silty clay loams. Therefore it can be concluded that the changes in the state of soil aggregation are caused by factors other than textural properties *per se*.

Soil Rehabilitation

The improvement of the soil aggregate status by using suitable rehabilitation crops during replanting of tea appears to be very important. At Borbhetta Field Experimental Station, the Senior Agriculturist has laid out 50 museum plots with different species of grasses, leguminous cover crops and some of the common weeds, to screen them as rehabilitation crops from his agronomic viewpoint. Use of these plots has been made for studying the changes in physical and chemical properties of soils.

From the first batch of chemical and aggregate analyses carried out on top 15 cm (6 in.) soils, after one and a half years rehabilitation, 12 different species have been found to be promising from the Soil Chemist's viewpoint. These species have improved the soil aggregate status vividly (varying from a 35 to 58 per cent increase), and in order of soil aggregate improvement they are :

Borreria hispida, Digitaria decumbens, Tripsacum laxum, Paspalum dilatatum, Digitaria eriantha, Tephrosia candida, Pusa-giant Hybrid napier, Pennisetum purpureum, Chrysapogon gryllus, Eleusine hispida, Cenchrus ciliaris, Tephrosia vogellie.

Top soil samples from the 15 cm (6 in.) layers were also collected in September 1967, from the Senior Agriculturist's Soil Rehabilitation Experiment laid out at Borbhetta. One and a half year's fallowing, irrespective of the nature of the cover crops used, has increased the total soil aggregate percentages in comparison with those plots which were not uprooted and still carry the original tea. The maximum increase in total soil aggregates was caused by *Tripsacum laxum* (Guatemala grass), whereas the effects of *Mimosa invisa, Imperata cylindrica* (thatch), and mixture of *Tripsacum laxum* and *Mimosa invisa* were found to be lesser but equal to each other. Also the effect of rehabilitation on the formation of coarse soil crumbs (over 2 mm in size) is prominent.

Complete soil exposure for six months without rehabilitation has considerably deteriorated the level of total soil aggregates. Removal of the ground cover provided by a mature stand of tea followed thereafter by cultivation and exposure for a period of six months, reduced the total soil aggregates from 55.91 per cent to 37.73 per cent.

Plots rehabilitated with different cover crops for one year were thereafter exposed for a period of six months. The exposure was caused by the removal of the cover crops and subsequent replanting of new tea. Compared to the aggregate status of soils under a mature stand of tea (55.91 per cent), the rehabilitated and subsequently exposed soils, had appreciably lower levels of total soil aggregates with the exception of the plots rehabilitated under Guatemala grass which maintained the same level of soil aggregates (54.77 per cent) as that of soils under a mature stand of tea.

It appears that considerable decrease in the soil aggregate status takes place due to complete exposure for as short a period as six months and this deterioration is not compensated by one year prior rehabilitation with any other crop than Guatemala grass.

Liming and Old tea soils

In a 40 year old tea section at Borbhetta (B/41.2), the Senior Agriculturist obtained good responses in yield from lime applications at the rate of one tonne per hectare in combination with nitrogen at the rates of 100

and 200 kg per ha during 1967. Two tonnes of lime was excessive. Estate experiments using similar treatments, conducted by the Chief Advisory Officer, however, did not show any responses to lime.

Soil samples from the Borbhetta experiment were analysed for aggregates, acidity, *readily available* calcium and *available phosphate,* since these are the soil factors likely to be affected by liming. The effect of lime at the rate of one and two tonnes per hectare has been found to be well marked only in respect of *available* phosphate and the available phosphate of both top (0—15 cm) and sub (15-30 cm) soils has increased as a result of liming. Soils from the estate experiments are still to be analysed.

Nevertheless the results from the Borbhetta trial point to the potential dangers of laying out new experiments at Borbhetta where soil treatments have been varied frequently in the past and thus the soils may now no longer be representative of estate soils.

Soil Water

The research programme in relation to soil water has fallen behind schedule due to delays in receiving a pressure membrance and pressure plate apparatus.

The cause of the unexpected behaviour of gypsum blocks (see Annual Report, 1966, pp. 19-23) could not be studied because of other engagements demanding immediate attention. However, as done during the last year, soil moisture was estimated gravimetrically from January, 1967 to April, 1968 in two of the Senior Agriculturist's Irrigation experiments at Borbhetta. The trends of soil water use with pruned and unpruned tea, with and without irrigation, have been found to be practically the same as those reported last year.

Agricultural Meteorology

A comparative study was carried out with two ordinary type 13 cm (5 inch) raingauges, one mounted on a cement concrete base at ground level (standard) and the other simply mounted on grass. The tops of both raingauges was maintained at 30 cm (1 ft.) above ground level. Rainfall has been measured by these methods at Tocklai, Silcoorie, Nagrakata and Nagri Farm. The raingauges mounted on grass recorded higher total yearly rainfall both at Nagrakata and Nagri Farm, compared to the standard ones. During the monsoon months (from June to October), the raingauges mounted on grass recorded higher rainfall than the standard

ones at all the four meteorological sites. During July, when monsoon showers reached peaks then the gauges mounted on grass recorded 64.0 mm (2.5 in.) more at Nagrakata, 25.8 mm (1 in.) more at Nagri Farm, 12.6 mm ($\frac{1}{2}$ in.) more at Silcoorie and only 2.2 mm (0.1 in.) more at Tocklai compared to the standard ones. the matter needs further investigation

A crude comparative assessment of evaporation has been made at Tocklai under different environmental conditions, namely in the open, under a bamboo screen and under a shade tree (*Albizzia chinensis*) using Piche Evaporimeters. Measurements were made during the dry period of 1966/67, i.e., December to April. The evaporation under a bamboo screen was found to be least throughout the dry period and less by 0.4 inches for five months compared to the Piche in the open, but this is not substantial.

Simultaneous measurements of dew at Tocklai for seven years comparing a simple Duvdevani gauge and a sophisticated Hiltner type dew balance have shown that cruder gauge estimates are sufficiently accurate for aggricultural purposes. Therefore, an attempt was made to find out the differences in dew deposits from long-term gauge data recorded at Tocklai, Silcoorie, Nagrakata and Nagri Farm from October to February. For all the five months the estimates of dew are higher at Tocklai and Silcoorie than at Nagrakata and Nagri Farm. Total dew deposits in five months have been found to be 23.4 mm (0.9 in.) and 29.9 mm (1 in.) at Tocklai and Silcoorie respectively as against 10.6 mm (0.4 in.) and 3.3 mm (0.1 in.) at Nagrakata and Nagri Farm respectively. Maximum dew deposition takes place from November to January, when the rainfall is at its lowest at all the meteorological sites.

Penmen analysis of meteorological data has continued. Calculatious have been issued as a meteorological bulletin, where meteorological conditions for ten day units have been given for as many years as meteorological measurements are available for all the meteorological sites.

Observations continued throughout the year comparing readings of a sunshine recorder and an anemometer installed at a height of 6.5 m (21 ft. 6 in.) above ground level against standard installation with the sunshine recorder at 1.2 m (4 ft.) and the anemometer at 3 m (10 ft.) above ground level. The sunshine hours recorded at both heights show good agreement. The anemometer at 6.5 m height measured consistently higher wind runs than the standard 3 m height.

A summary of meteorological observations during 1967 for all the four sites is given in Appendix D.

Advisory

Setting up of the chemical laboratory on a semi-automatic basis for routine soil testing has been completed. As a direct effect of this improvement, it was possible to analyse double the number of routine soil samples from tea estates than in the previous year. More detailed soil analyses were undertaken for special reasons on many occasions.

BOTANY DEPARTMENT

RESEARCH & EXPERIMENT

Plant Improvement

The decision to release the first biclonal seed stock produced at Tocklai was taken during the year. The occasion calls for a brief review of the history of plant improvement in the tea industry of North East India and the programme of tea breeding undertaken by this Station.

The credit for introducing the Assam *jats* of tea to the tea industry goes to a few amateur plant breeders who came to Assam as Managers of tea estates. These amateur breeders selected seedlings of the indigenous plants mainly on leaf characters, and established seed baris with the selected seedlings. Further selection among the progenies of these seed baris led to the isolation of the modern Assam *jats* well-known for their superior liquoring characters under the Orthodox system of manufacture, that being the only system practised in the past. But the breeders with their mass selection technique failed to raise hardy *jats* having cup-quality equal to that of the good Assam *jats*. Hardy *jats* are required for the drought-prone areas of the Dooars, Terai and Cachar where the delicate Assam *jats* do not flourish. An entirely different kind of China tea is required for Darjeeling.

After reviewing the situation as it existed at the time, the 1934 Commission of Enquiry headed by Sir Frank L. Engledow, F. R. S., suggested a tea breeding programme at Tocklai to standardise the planting material and to improve the standard of North East Indian tea by producing superior clones and *jats*.

To achieve these objects two separate lines have been followed at Tocklai :

(1) Breeding of improved seed varieties
(2) Selection of superior bushes from among the existing tea populations and their *vegetative* multiplication as clones.

The work on plant improvement, started in 1939, was interrupted by the War and could only be taken up again in an organised way from 1946.

(1) Breeding of improved seed varieties

The production of improved seed varieties in a cross-breeding, peren-

nial crop like tea is a very long-term project, particularly when one generation takes 6 to 7 years from seed to seed. Two methods were initially followed for the breeding of improved seed varieties :

(a) **Establishment of polyclonal baris,** where more than two selected clones are inter-planted in a lattice design. The seeds resulting from open, random pollination are tested for germination and the plants for growth, yield and cup characters.

Four polyclonal seed baris were originally planted in isolation, each with 9 clones, but one bari was destroyed during the War. Of the remaining three, one produced a dark-leaf *jat* which makes tea of as good quality as the good light-leaf Assam *jat*. This polyclonal stock was retained as a source of seed for the droughty areas of the Dooars, Terai and Cachar The *jat* is known as Tocklai Stock 203 (produced under the scheme Gaurishankar). Eight commercial estates have planted from 1 to 8 hectare each of this polyclonal seed bari since 1954 with 7 clones, (two being subsequently discarded from the original nine) and a total of approx. 30 ha of seed bari of this stock are now in bearing. The seeds produced by these baris have been fully utilised for replanting and extension, mostly in N. E. India and a small proportion in South Indian estates.

The other two polyclonal baris did not show promise and were destroyed.

In 1966/67 another polyclonal seed bari was established with 8 selected clones.

(b) **Production of biclonal seed**

This method consists in crossing two selected bushes by hand transfer of pollen and trying out the resulting progeny for growth, yield and cup-characters. If the progeny is found satisfactory, the two parent bushes are then multiplied vegetatively and planted in isolation as a small, biclonal seed bari for the production of seed by open, random pollination under natural conditions.

Out of nearly 400 crosses made by hand pollination, six were selected before 1962 for planting micro seed baris. Six more crosses have been selected subsequently. Seeds from the six baris established before 1962 are now undergoing trials at Borbhetta and in a number of commercial estates in N. E. India. On the results of these trials, the first of these biclonal stocks (No. 378) has been selected during the year for release to the Industry.

Stock 378— Produced under the breeding scheme "Nanda Devi".

This is a chinery stock which produces a tea having the same flavour as the high-grown Darjeeling teas, but the flavour of this stock is more pronounced. This stock will be suitable for growing in Darjeeling, particularly at elavations where flavoury teas are made. The stock has bigger leaves and thicker shoots than the traditional high-grown Darjeeling bushes and its yield potential is also higher.

Arrangements have been made to produce seed of this stock both at Tocklai and Nagrakata in quantity sufficient for the Darjeeling growers. The newly planted or grafted baris are expected to come into production from 1971.

A decision regarding the release of the remaining five biclonal stocks under trial will be possible in the course of the next two or three years.

(2) Selection of vegetative clones

The selection of outstanding bushes from the existing tea populations and their multiplication as clones is a relatively simpler matter than breeding of seed varieties. Progress made in the selection and release of clones by Tocklai has been reported from time to time. More clones are being selected for release to the Industry, besides the 15 already released till 1967.

At present, selection has mainly been confined to the progenies of the biclonal crosses, and special attention has been paid to the isolation of bushes having very high potential for yield and a level of quality at the least equal to that of the best commercial *jats*.

More than 50 promising clones are undergoing trials at Tocklai and more clones were selected during the year for trials. The clonal proving station in Darjeeling has commenced testing clones suitable for the Darjeeling area and a few China clones showing promise were selected at Tocklai during the year for trial in the Darjeeling proving station.

Breeding behaviour and cytology

The primary duty of the Plant Breeder since his appointment early in the year was to scrutinise the past records of tea breeding at Tocklai with a view to deriving, if possible, principles of inheritance in tea and formulate new lines of investigation for genetic improvement of the tea plant. His scrutiny so far has suggested that the relationship between parents and progeny in yield and cup characters, reported in the Ann.

Rep. for 1965 page 36, needs re-examination on a wider scale and accordingly a new set of manufactures has been planned for the 1968 season to verify the parent-progeny relation in quality.

Some experimental pollinations were carried out to provide information on the breeding behaviour of tea and to establish a few pure lines. In the meanwhile the method for the examination of tea chromosomes was standardised and cytological examination was carried out on a number of clones differing widely in leaf characters, growth, yield and quality.

A normal functional cell of a tea plant contains two sets of 15 chromosomes each. In rare cases there can be three or more sets of chromosomes, a condition known as polyploidy. Increasing the sets of chromosomes by treatment of the cells with certain chemicals has become an important tool of the Plant Breeder for improving crop plants. These methods have also been tried on tea, but so far without much success.

It has, however, been possible to demonstrate the existence of natural triploids (45 chromosomes) and tetraploids (60 chromosomes) among the clones existing at Tocklai.

Treatment of tea seeds with mutagenic rays through the courtesy of Indian Agricultural Research Institute, New Delhi, and the Atomic Energy Establishment at Trombay has also been tried, but the treated seeds in every case have failed to germinate, in spite of all care. The reason for this failure is being investigated.

Clonal criteria

Lack of objective criteria for recognising and differentiating clones and *jats* and for assessing their liquor characters has been a great handicap in the programme for plant improvement. Realising the necessity of such criteria, various indices were devised in the past to differentiate *jats* and clones and also to correlate liquor characters with morphological and anatomical features. Unfortunately none of these indices has proved to be of much value as they are either highly subjective or involve very large experimental errors.

Nevertheless and in spite of these past difficulties, a Plant Breeder must have at least a few key characters to differentiate progenies and clones and also to obtain some indication of their growth and liquor characters at an early stage of growth.

In a fresh attempt to provide the Breeder with a few diagnostic characters for clonal differentiation, a large number of morphological, anatomical and physiological characters of a number of clones, known for their growth

and liquor characters, are being measured quantitatively. On completion of the projected measurements, the data will be analysed in a computer in the hope that some characters important for the purpose of differentiation and correlation with growth and liquoring properties will be isolated.

In its search for objective criteria, the Department actively cooperated in the execution of the project C 5 of the Biochemistry department, which was an attempt at correlating tasters evaluation of liquor characters with biochemical attributes. It is not certain at this stage of analysis of the data whether this experiment will provide any readily estimable objective criteria to the Plant Breeder.

Another experiment was designed and carried out partly for the same purpose. In this, the different components of plucked shoots, buds, first leaves, second leaves, stems etc. from a seed-grown section of tea, were separated and manufactured individually on four occasions between early June and early October. The contribution of each component towards the total weight of the pluckings was also determined. The teas were tasted independently by the Manufacturing Adviser & Tea Taster and a Calcutta taster against controls made from whole shoots. A summary of the results is given in Table 1.

Table 1. Valuations according to the components of shoots, expressed as averages of Tocklai and Calcutta tasters

Shoot component	Valuation Paise/kg	Per cent dry wt. of the shoot components	Per cent contribution of the components to total value
Bud	1138	11.47	18.08
1st leaf	902	20.46	23.75
2nd leaf	594	28.92	21.86
3rd leaf	558	9.76	7.83
Stem	724	15.82	17.41
Banjhi shoots	624	13.57	11.07
Whole shoots (Control)	782	—	—

Knowing the valuations of the individual components and their proportions by weight, it is possible to calculate the theoretical value applicable to the whole shoot and this equals Rs. 7.41 per kg. The controls

manufactured from whole shoots (and not component parts separately) gave an average valuation of Rs. 7.82 per kg, and this bears a close similarity to the theoretical figure of Rs. 7.41. Agreement between the theoretical and actual valuations of the control whole leaf samples was even better when tasting reports received after publication of the data in Table 1 were taken into the calculation of the average values.

An interesting hypothesis that follows is that the taster unconsciously feels from the taste the proportions of each of the shoot components in the cup and mentally sums up the taste arising from the different components in evaluating a sample of tea manufactured from whole shoots. The limited number of experiments, therefore, give strong indication that tasters evaluations are indeed additive. For confirmation, a longer series of experiments are planned for 1968, using leaf from a clonal field.

These tasting results viewed in the context of another experiment reported in the Ann. Rep. for 1957, pages 69-75, seem to suggest that one of the reasons for the fall in quality of the rains teas is a decrease in the proportions of the finer fractions and a corresponding increase in the coarser fractions of the plucked shoots.

Plant Physiology

The main item of interest during the year was the determination of photosynthetic rates at different temperatures using an Infra-Red Gas Analyser and controlled environment cabinets. This series of experiments, carried out at Cambridge University, led to an explanation of the benefits to be derived from using suitable shade trees on the type of tea normally grown in North East India and the lack of response to shade in most other tea growing countries. It appears that the major function of an overhead canopy is to reduce leaf temperatures during periods of high insolation but this reduction of temperature is invariably accompanied by a reduction of light intensity. The critical leaf temperature is approximately 35°C and above this temperature the rate of net photosynthesis decreases rapidly until at 40-42°C there is no net photosynthesis and the leaf is living by using up reserves manufactured during more favourable conditions. The cooling effects of winds may not be as marked in N. E. India as in some other countries where tea is grown and for which reliable meteorological data are available. For horizontal leaf type bushes the only practical method of keeping leaves below 35°C is by shading, but shading in such a way that light does not become a limiting factor. The overhead canopy should in N. E. Indian plains, therefore, be thin enough to allow at least 50 per cent of full noon radiation to reach the tea bushes underneath as reported in the past (Ann. Rep. for 1957, page 43).

The corollary of the laboratory studies is that where net photosynthesis is not limited by high leaf temperatures, a condition when air temperatures of 30°C and above are not combined with long periods of bright sunshine and still air, unshaded tea should produce higher yields than shaded tea, but that when high radiation and high temperatures combine, shade will be beneficial. From the law of limiting factors it should follow that if there is insufficient light for optimum production, an increase of nutrients will have no effect, and if high leaf temperature is the limiting factor, nutrients will again have no effect.

A large field trial on a local estate has provided some support to these conclusions by producing higher yields in unshaded plots in 1966, when periods of bright sunshine and high temperature were lower than in 1967, when the shaded plots gave the highest yields. Shade must, therefore, be regarded as an insurance policy against adverse climatic conditions and the premium will consist of the amount of crop lost by shading in those years when it is not required.

The work on leaf pose and light penetration, which has been reported previously (Ann. Rep. 1966, pages 40-43), complements the leaf temperature and shade work in providing a general theory relating morphological features of the bush (leaf pose), physiological responses (respiration and photosynthesis) and environmental factors (sunshine, air temperature, and wind run) with yield response to various management practices.

Field experiments testing the main features of the theory have demonstrated that erect leafed types of tea respond better to higher rates of manuring and irrigation than horizontal types and that their yield is reduced under light artificial shade, whereas horizontal types increase yield under light shade.

In one small plot a yield of 5600 kg/ha was obtained by application of very high doses of nutrients combined with intensive irrigation on an erect leafed clone, while the same treatment almost killed a horizontal leafed clone which was planted in alternate rows with the erect type.

While a lot of detailed work remains to be done on the aerial parts of the tea bush, it is suspected that major advances in productivity await a fuller knowledge of the uptake mechanisms, both of water and nutrients, by the root system, which in turn requires a detailed knowledge of soil structure, aeration and nutrient levels of all major types of tea soils.

The reasons for this suspicion were further strengthened by a simple experiment reported last year which clearly demonstrated the harmful effects of a continuously high water table on root and top growth of young tea plants (Ann. Rep. for 1966, p. 38). When the experiment was repeated this year under conditions of a fluctuating water table, i. e. high one week and low the following, no improvement in growth could be observed; both root and shoot growth were restricted to the same extent as in the previous experiment with a continuously high water table.

Much agronomic and soils work is, therefore, required, particularly on the root environment of the tea bushes before the fundamental knowledge of the aerial environment acquired in recent years could be fully utilised for increasing productivity. Laboratory studies linking root environment and photosynthetic rates are planned for 1968.

Spacing of plants : Clones differ in their growth characteristics; some have spreading and others an upright habit of growth. Growth and spread are also affected by soil fertility, nutrient and water supply, drainage, incidence of diseases and pests etc. Hence it is not possible to determine the optimum space requirement of different clones under diverse field conditions by carrying out a spacing trial in one area.

An alternative but simple approach to the spacing of clones has been tried by recording the number and the pattern of distribution of the plucking points on the bush surface. The outcome of this study will be known only after the observations have been verified in the field on bushes planted at different spacings.

General

Survey of the growing stocks in N. E. Indian tea estates

A survey was conducted in 1966 through a questionnaire to obtain information on the kinds of plants grown in N. E. India and their longevity under diverse conditions of soil and climate. The questionnaire was sent to all Member estates of the T. R. A. in the plains of N. E. India (excluding Tripura) and 41.3 per cent of the estates replied, representing 12.8 per cent of the area of the Member estates and 32.8 per cent of the total area under tea belonging both to the Member and Non-Member estates.

Analysis of the replies showed that the area planted with clones before 1960 was negligible. The areas planted between 1950 and 1965 with seed and clones are shown in Table 2.

Table 2. Areas planted by the sampled estates between 1950 and 1965 expressed as percentage of the total areas under tea in the sampled estates of different districts

Tea District	Per cent area-planted between 1950 and 1959	Per cent area planted between 1960 and 1965			Total percentage of area planted between 1950 and 1965	Mean planting rate for the period 1950 to 65(Per cent area per annum)
	Total of seed and clone	With seed	With clone	Total of seed and clone	Total of of seed and clone	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Assam : South Bank	14.0	8.8	2.9	11.7	25.7	1.60
Assam : North Bank	15.3	9.6	0.7	10.3	25.7	1.60
Dooars & Terai	10.1	9.5	1.3	10.8	20.9	1.30
Cachar	13.4	9.4	0.1	9.5	22.9	1.43
Mean of all districts	13.0	9.2	2.0	11.2	24.2	1.51
Mean planting rate (Per cent area per annum)	1.30	1.53	0.33	1.87	1.51	

The table, which includes both new extensions and replanted areas, is self explanatory. It is of interest to note that the average planting rate for the 1950-59 period was 1.30 per cent per annum which rose to 1.87 per cent per annum during the 1960-65 period. Of this 1.87 per cent, clones accounted for only 0.33 per cent per annum or roughly one-fifth of the total newly planted areas, the remaining four-fifths being planted with seeds. The great variation between districts in the rate of utilisation of clones can be seen from column (4).

If the data is extrapolated to include all Member estates of the T. R. A., occupying 76.7 per cent of the total tea areas in the plains of N. E. India, then the area planted with clones till the end of 1965 works out at 3477 hectares which is a meagre 2 per cent of the total Membership area.

Non-Member estates making use of clonal material are rare and it is highly improbable that more than 100 ha have been planted with clones by the Non-Member estates comprising the remaining 23.3 per cent of the total area under tea in the plains of N. E. India.

ADVISORY

Touring : Dr. D. N. Barua visited three estates in Upper Assam. He also visited UPASI Sci. Dept. of South India in February and Kanan Devan Hills Produce Co. Ltd. of South India in May. Mr. W. Hadfield visited one estate in Upper Assam and also visited Murmuria Tea Estate on a number of occasions in connection with the large scale shade × manurial trial. Mr. H. P. Bezbaruah visited one estate in Upper Assam, two estates in Darjeeling and three estates in the Dooars.

Study leave : Mr. Hadfield spent six weeks at Cambridge University working on the effects of temperature on respiration and photosynthesis of the tea leaf.

Meetings : Dr. D. N. Barua attended five meetings of the Scientific Sub-Committees during the year. He also attended a meeting of the Standing Committee for Agricultural Research of the I. C. A. R. in New Delhi in August. Mr. W. Hadfield attended a meeting of the Scientific Sub-Committee. Mr. H. P. Bezbaruah attended a Scientific Sub-Committee meeting at Darjeeling in June.

ENTOMOLOGY DEPARTMENT

Tea Mites

Studies on the susceptibility of different Tocklai released clones (TV 1-TV12) to scarlet mite, *Brevipalpus phoenicis* Geijskes, were made at Borbhetta during March to December by counting the mite populations on 50 randomly selected leaves drawn each month from each of the twelve clones. The results show that clones TV1 and TV7 appear to be prone to scarlet mite attack, but this is subject to confirmation by further observations.

Distribution of scarlet mite on skiffed and pruned tea, young (5 years) and mature tea (18 years), bushes in well drained and poorly drained areas, and also on Assam and China types of tea was investigated.

Skiffed tea in general had more scarlet mites than pruned tea, but no significant difference was found in scarlet mite populations on the young and mature tea. Populations of scarlet mite on bushes in well and poorly drained areas did not differ significantly, though last year, in general, a significantly high population of red spider was recorded on bushes in poorly drained areas.

Red spider and scarlet mite also appear to behave differently in their preference for *jats* of tea in this year's observations which show that unlike red spider which occurs more on China *jats*, scarlet mite seems to have no such preference. The investigations on scarlet mite will, however, have to be continued for confirmation.

Comparative ecology of the four common mites of tea, viz. red spider, *Oligonychus coffeae* (Nietner), scarlet mite, *Brevipalpus phoenicis* Geijskes, purple mite, *Calacarus carinatus* (Green) and pink mite, *Acaphylla theae* (Watt) Keifer, is being studied at the Murmuria experiment. In this Botanical Department experiment the tea receives different fertilizer treatments, half is shaded with *Albizzia odoratissima* and the remainder unshaded.

Specieswise weekly records of the mite populations according to field treatments are being maintained. The observations were started in 1966 and will have to be continued for one more year. Although detailed statistical analysis is awaited, the first two years' data indicate that irrespective of shade treatments, plots manured with NPK had least red spider and purple mite, though not significantly so in case of red spider. Purple mite population was almost double in plots treated with 112 kg ha of Nitrogen (N) alone compared with plots manured with a full NPK mixture.

Tea Aphid

Seasonal population studies on the aphid, *Toxoptera aurantii* Boyer, indicated that the population reached its peak during January to March when new shoots were growing and then it slowly dropped. During the cold months of November and December the population stayed very low, increase being first noted again in the middle of January.

Biological studies of this aphid include a search for its predators and parasites which keep the population of the pest under check in the field. One larva of a predatory Syrphid fly, *Syrphus balteatus* De Geer, consumed 450 aphids during its entire larval period of 10 days and the daily feeding capacity of the whole larval population varied between 22 and 45 aphids per larva. The larva of an yet unidentified Syrphid fly was a more voraceous feeder still and consumed 486 aphids in only four days in captivity.

The predatory beetle, *Cryptogonus bimaculata* Kapur, consumed 1,896 aphids during its life time of about five months in the laboratory. The larva of this beetle is also an efficient predator; a single larva feeding on about 200 aphids in 10 days.

The larva of a Neuropterous predator, *Micromus timidus* Hogen, consumed 116 aphids during its larval period of seven days in the laboratory.

A trial for the control of Aphids was carried out in the field with 0.16% of Thiodan 35% E. C., 0.04% of Rogor 40% E. C., 0.025% of Metasystox 25% E. C. and 0.07% of Chlordane 70% E. C. along with untreated control series. All the insecticides except Chlordane gave efficient control of aphids within 24 hours of application.

Investigations are in hand to find out the effect of modern insecticides on the preservation of natural enemies of aphids.

Bunch caterpillars of tea

Caterpillars of the moth, *Andraca bipunctata* Wlk., are one of the most serious leaf eating pests of tea. A diurnal variation in their feeding and aggregating behaviour has been observed. The caterpillars feed singly during the night and aggregate during the day when they are not feeding. The starved caterpillars did not aggregate until they had first fed well and aggregating tendency was strongest amongst the late instar caterpillars. Oviposition, hatching, moulting and emergence of moths occurred only after dusk and stopped before 24.00 hrs. (I.S.T), the peaks usually occurred between 19.00—20.00 hrs. (I. S. T.). Oviposition continued for three nights.

Tea Jassid

A field experiment which was carried out for the control of Jassid, *Empoasca flavescens* Fabr. showed no difference in control between 0.2% of Mesurol 50% W. P., 0.1% of Metasystox 25% E. C., 0.05% of Metacid 50% E. C., 0.05% of Follidol- E605, 46.7% E. C. and 0.1% of Morestan 25% W. P., but all these treatments were significantly superior to untreated control.

Tea Thrips

Scritothrips dorsalis Hood which is a common thrip in the plains, causes damage to young shoots and buds of tea by sucking. Nymphs cause more damage than the adults. Field observations showed that thrips were most active in the morning and evening; during the intervening period they remained hidden in the folds of leaves and buds.

Nettle Grub

A Pentatomid bug, *Cantheconidea furcellata* (Wolff), was found in the field predating on different species of nettle grubs, particularly *Parasa pastoralis* Butl. Other species of nettle grubs involved in the predation by this bug were *Thosea cervina* Moore, *Trichocrisia nigrimargo* Her. and the common jelly grub, *Cheromettia apicata* Moore. The first instar nymph of the bug did not predate, but the second to fifth instar nymphs were predaceous. The life cycle of the predating bug was completed in about 50 days in October to December in captivity.

Pests of shade trees and green crops

Sternocera sanosignata Oliv. is a serious root damaging pest of *Albizzia odoratissima* in the North Bank. It is also common in the Nowgong district.

Field observations showed that eggs were found during late August to February. The grubs were abundant at a depth of 10-25 cm, only a few being found at 50 cm. Larvae in various stages of development were abundant during January to June but a few grubs could be found even after this period owing to overlapping of the oviposition periods. Pupation took place in the soil in a pupal chamber made by the 4th instar larva with soil and decomposed vegetation at a depth of 10-25 cm and within a diameter of 15-20 cm from the root. Adults were most numerous during August to October. The life cycle was completed in the laboratory in about 11 months.

Two species of Bostrychids were isolated from the branches of *Albizzia odoratissima, A. procera, A. lebbek* and *Derris robusta* in the Dooars. Populations of various larval instars and adults were found within the branches of shade trees Life history studies of the two species have been taken up in order to find out their destructive stages and to what extent they could depredate the shade trees. Bostrychids have also been recorded for the first time from tea seed baris.

Crotalaria anagyroides HBK, has been found to be damaged by the larvae of a moth, *Etiella zinckenella* Tr. The larvae bore into the pods and destroy them. The incubation, larval and pupal periods of the pest in the laboratory in April were 7, 10 and 12 days respectively.

Nematology

A preliminary survey of the eelworm infestations in tea nurseries, mature tea sections and green crops was conducted in the Dooars, Darjeeling and Assam. Apart from the well known root knot nematodes, *Meloidogyne* spp ,different species of endoparasitic (*Pratylenchus*) and ectoparasitic (*Rotylenchus, Tylenchorhynchus* and *Tylenchus*) nematodes were isolated from young tea nurseries and green crops. Other ectoparasitic nematodes of *Paratylenchus* spp. were found in the soil around the roots of mature tea bushes, above 20 years old. Although the taxonomic assessments of all the nematodes have not yet been completed, the following is a list of some of the new records from North-East India.

Scutellonema brachyurum (Steiner) Andrassy
Macroposthonia ornata de Man (?)
Pratylenchus brachyurus (Godfrey) Goodey.
Pratylenchus sp. novo. ?
Paratylenchus curvitatus v.d. Linde.
Aphelenchoides composticolla Franklin.
Xiphinema insigne Loos.
Tylenchus agricola de Man (Andrassy)
Meloidodera floridensis Chitwood, Hannon & Esser.
Tylenchorhynchus mashoodi ?
Hoplolaimus columbus Sher.
Aphelenchus agricola de Man.

Although all the species might not be of consequence in tea growing, the pathogenicity of *Pratylenchus brachyurus* in tea seedlings has been established. It penetrates deep into the roots of seedlings and causes deep red lesion marks at the points of infestation. The infestation persists even on two to three year old seedlings.

Sampling for *Paratylenchus* sp. from around the root zones of mature tea (20 years) was done at depths of 10 cm, 20 cm, 30 cm, and 60 cm, and at distances of 20 cm, 40 cm, and 60 cm from the collar. The vast majority of the eelworms found were distributed within a depth of 10 to 20 cm and at a range of 20 to 40 cm away from the collar. This indicates that they were distributed mostly in areas colonised by feeder roots. These eelworms stayed around the tips and surfaces of the feeder roots and in the process might stop the roots from absorbing water and nutrient from the soil.

Apart from *Paratylenchus*, several other groups of nematodes have been isolated from around the roots of mature tea and the distribution of these and *Paratylenchus* at a depth of 20 cm and at distances of 10, 20 and 30 cm away from the collar of mature tea is shown below. Counts from adjoining grassland and Guatemala grass plots are also given.

Table 1. Distribution of some ectoparasitic eelworms

Eelworm Groups	Average no. of eelworms/100 g. of soil collected from :—					
	mature tea section, 20 cm depth				Guatemala grass plots, 20 cm depth.	Grass havel adjacent to mature tea, 20 cm depth.
	10 cm away from collar	20 cm away from collar	30 cm away from collar	Totals		
Dorylaimids	280	100	60	440	120	320
Hoplolaimids	0	0	20	20	0	60
Paratylenchids	160	400	220	780	0	20
Rotylenchids	40	0	100	140	200	400
Saprophagous	60	80	60	200	420	520
Tylenchids	160	0	40	200	320	560

It is to be noted that Paratylenchids which are ectoparasitic eelworms, and found in large numbers in the rhizosphere of mature tea, were least under Guatemala grass. However, no generalization should be made on this data because intensive investigation on the distribution of eelworms in soil under various rehabilitating plants is still under way.

Populations of ectoparasitic nematodes in mature tea areas reached their peaks during January and March (1967). Thereafter there was a gradual decline in population until June, when the upward trend was resumed, but it died down again in July.

Soil Biology

Studies were made during June to December on the seasonal distribution and abundance of the microfauna of the soil collected from areas having bushes less than 5 years, between 5-10 years, between 10-15 years and above 20 years old. The soil samples were processed in the laboratory using a Tullgren funnel. In all cases soil mites and insects were most abundant and active during July to October after which their populations declined.

MYCOLOGY DEPARTMENT

During the year studies on the chemical control of red rust, black rot, branch cankers including *Poria* and *Tunstallia* were undertaken. Observations were also made on the role of fertilizer applications on the progress and development of thorny stem blight (*Tunstallia*) and black rot (*Corticium invisum*). The relationship between shade and nutrients in disease development was also studied in collaboration with the Botany Department. Aerobiological studies were made with particular reference to black rot and red rust spores.

Six chemical formulations of fungicides namely Copper Sandoz (Cuprous oxide), Blue Copper Sandoz (Copper oxychloride), Emulsifiable Copper (BPM), Orthodifolatan (Chevron chemicals) Bayer 5191 and Euparen (Bayer) were screened for the effects upon red rust and black rot.

The experiment on red rust was laid in a nearby tea estate in the Jorhat circle showing severe red rust incidence and the six formulations described above were tried using a knapsack sprayer. Two rounds of spraying were done with an interval of two weeks between them in the month of May. Counts were made on two occasions during mid and late June.

At both counts, the amount of infection was reduced significantly by Copper Sandoz, Blue Copper and Orthodifolatan treatments. Euparen showed a significant reduction at the second observation but not in the first. Though this chemical offered statistically better protection, than the control, it does not appear to be practically useful. Orthodifolatan compared favourably with the standard, normally recommended Copper formulations, in its efficiency in controlling the disease.

The experiments on black rot were laid in two different estates, one in the Jorhat circle and the other in the Sonari circle. *Corticium theae* was the causal organism in the Jorhat circle and *C. invisum* in the Sonari circle. All the six formulations mentioned above were sprayed twice with an interval of two weeks between them in the Jorhat circle, but Euparen was omitted from among the chemicals sprayed in the experiment in the Sonari circle. A knapsack sprayer was used at both areas. Observations were made on two occasions during July and August. The results were as follows. :

Although tea area in Jorhat was severely infected at the time of pretreatment assessment in the previous year, September 1966, the development of the disease was low during the season following spraying and therefore no definite conclusion can be drawn.

One possible reason for the low incidence of the disease in the current year may be the control measures taken by the management in the previous year, the effects of which persisted. Another possibility is that the climatic conditions in this area during the year were not favourable for the growth of the fungus.

Copper Sandoz, Blue Copper and Orthodifolatan significantly reduced the rate of infection of *C. invisum* in comparison with the untreated plots in the Sonari circle.

From the studies made during the year 1965 and 1966 it was clearly seen that the control of red rust was better when the chemicals (mainly the copper fungicides) were applied using a power spraying of the Fontan type in comparison with the normally used hand operated, pressure retaining knapsack sprayers.

To compare the effects of different sprayers when used for spraying against black rot, (as opposed to red rust) an experiment was conducted in which Copper Sandoz was sprayed at the rates of 2.5 kg/ha and 4.5 kg/ha using the Fontan and at 4.5 kg/ha using hand operated pressure retaining knapsack sprayers. Two rounds were applied in May and observations were made twice, once each in July and August. The results indicated that the fungicide when applied at 2.5 kg/ha with the Fontan sprayer offered equal control of black rot as the 4.5 kg/ha sprayed with a knapsack sprayer.

Branch canker : Among the slow growing wound parasites on tea, two are the most common, namely *Poria* (*P. hypobrunnea* = *P. punctata*) in the plains and thorny stem blight (*Aglaospora aculeata* = *Tunstallia aculeata*) in Darjeeling. This disease is comparatively rare on tea growing areas on the plains.

Poria gains entry into the tea bushes mainly through unprotected pruning wounds, sun-scorch lesions and broken off branch wounds. It spreads downwards until it reaches the collar region and the roots, and the bush eventually dies. The normal estate practice is to protect large pruning cuts by painting with Indopaste which is a bitumenous paint.

Aglaospora enters into the bush by two ways : (i) by air-borne spores deposited on unprotected wounds and (ii) by spores deposited by pruning knife blades which earlier in the process of pruning have cut through the fruit bodies (perithecia) of the fungus in the wood tissues of an affected bush.

During 1966 there was an acute and worrying shortage of Indopaste and this experiment was conducted to slect an alternative. The experiment was laid out at Tocklai on medium pruned, mature tea bushes. The treatments employed were (i) Santar 'A'- an aresenical compound formulated by Sandoz, (ii) Esso Tree Grease, (iii) Indopaste and (iv) a ten percent wt/volume paste of Blue Copper in water. These chemicals were applied with a brush in December 1966 immediately after the medium pruning. Observation thereafter showed that surface callus formation was more pronounced with Indopaste than with Esso Tree Grease. Practically no surface callus was noticed on the cut surfaces treated with Santar 'A' and the Blue Copper paste. However, callus had developed in the cambial region 1 to 2 mm below the surface treated with Blue Copper paste and Santar 'A'. None of the products tested are considered to offer as good a protection as Indopaste. Esso Tree Grease is preferable to the remaining treatments.

Thorny stem blight : Two experiments were laid out in Darjeeling in 1962 to study the effects of treating the pruning cut surfaces on the development and progress of the disease. In the conduct of this experiment Copper oxide (Copper Sandoz) and Copper oxychloride (Blitox) were sprayed on the medium pruned tea bushes. The cut surfaces were then further protected with Indopaste. These were compared with bushes that received Indopaste but no Copper fungicides.

Observations have been made over 5 years on the spread of the disease and indicate that the application of fungicide prior to Indopasting did not in any way give better protection against the disease than Indopasting alone. This emphasizes the necessity of protecting the freshly cut surfaces with Indopaste or any such suitable compound.

Potash manuring and black rot incidence

This experiment was laid out in collaboration with the West Bengal Advisory Branch on Baradighi T. E. in the Dooars to ascertain if manuring with potash reduces the incidence of black rot. The potash contents of the top and the sub soil of the experimental plots were estimated prior to the application of the fertilizers and the yield figures for the season were also recorded.

Regression analysis was done to see if there is any relation between soil potash, black rot incidence and yield but no significant relationship was found during this first year. The observations will continue.

N. P. K. manuring and its effect on Thorny stem blight (*Aglaospora Tunstallia*)

Observations are made for the second year in succession in Darjeeling to study the effect of NPK manuring on the development of thorny stem blight in an experiment conducted by the Darjeeling Advisory Branch on Sungma T. E. Phosphate manuring has resulted in a decreasing trend in the incidence of the disease, whereas potash manuring so far has caused no differences. Neither of the treatments offered statistically significant control during the first year after application. Long term effects of the manurial trials are continuing and further observations will be made during the next two years.

Aerobiology

With a view to organising a forecasting unit for the more efficient and effective spraying for the control of diseases, atmospheric spore counts were made during the year. The spore counts were recorded continuously by using modified Derham spore traps located at Borbhetta and Tocklai. Particular attention was paid during this early work to red rust and black rot spores. From the data so far collected it is clearly indicated that our present recommendations for spraying two prophylactic rounds of fungicides (Copper oxide or Copper oxychloride) during April and May against red rust, and black rot are inadequate. Spores of both the diseases are dispersed in the atmosphere for far longer periods than those suggested in our recommendations for prophylactic spraying.

During 1967, it was observed that the maximum number of red rust spores were dispersed on a day on which the maximum air temperature was 28.0 °C, relative humidity 75 per cent, rainfall 0.8 mm and 10 hours of sunshine. On a day when the temperature was 29°C, humidity 90 per cent, rainfall 92 mm and only 1.5 hours of sunshine, dispersal of black rot spores was very high. The work will continue.

PESTICIDE DEPARTMENT

RESEARCH AND EXPERIMENTAL

SCREENING OF PESTICIDES

Acaricides

The department concentrated its activities on the evaluation of new acaricides received in 1967 and also those which were under test against different mite pests of tea. A total of six new acaricides were evaluated against the four mite pests; red spider, scarlet, pink and purple mites.

Red spider

Prophylactic spraying of persistent acaricides is an effective measure of control against the build up of a potential population of red spider and other mites in a tea estate but it is not always a practical proposition to spray the whole estate. There are some areas in almost all estates, which are particularly prone to red spider or scarlet mite and it is essential that such areas are given regular prophylactic spraying.

In view of the above, the new acaricides Ethion, Trithion, Morocide and Morestan which have already proved excellent as palliative sprays were tried as prophylactics. Tedion was used as a standard for comparison. The experimental area was located in a section of mature tea and the acaricides were applied with a mist blower at the rate of 1.25 l/ha. After two months from application all the chemicals except Trithion reduced red spider population significantly. It can thus be concluded that persistence of Ethion and Morocide is comparable with that of Tedion and therefore they can be used prophylactically. It was also observed that Trithion and Morestan have low persistence and they cannot be used for prophylactic measures.

Scarlet Mite

In our preliminary trials against scarlet mite, Morocide, Ethion, Morestan and Trithion were found to be very promising as prophylactics (Annual Report 1966) and this year these new acaricides were evaluated for their effectiveness as palliative sprays Their application was done by mist blower with a rotary atomiser (Micronette) at the rate of 1.25 l/ha. All the acaricides within a month from first spraying were found to reduce the mite population significantly over the untreated control plots. Morocide, Ethion, Morestan, Trithion, Hexakel E. C. and Mesurol at the doses used were highly effective when used as palliative sprays against scarlet mite.

Pink and purple Mite

Kelthane E. C. and Tedion V-18 are known to be effective against pink and purple mites. Ethion 4 E and Morocide were found to be pro-

mising and gave good protection as did Kelthane and Tedion (Ann. Rep. 1965 and 1966). In order to compare the efficacy of Trithion and Morestan with that of Kelthane, Ethion and Morocide, a field trial was conducted between the months of February and March against a combined infestation of pink and purple mites in a section which was evenly and moderately infested with both the mites. Spray chemicals were applied at the rate of 1.25 l/ha with mist blower with rotary atomiser (Micronette).

Morocide, Kelthane, Morestan, Ethion, Tedion and Mesurol at the doses used, were highly effective and equitoxic for the control of pink and purple mites.

Esso tree spray oil and scorching

Esso Tree Spray Oil has been found to be very effective at the recommended doses against red spider, scarlet, pink and purple mites but during the year there were some reports of leaf scorching caused by spraying the oil with power sprayers on hot sunny days. In view of its inherently broad spectrum miticidal effect and also because it is cheap and readily available, it was thought that lower doses should be tried using different power sprayers and a Holder Harriden Knapsack sprayer to determine (i) whether a decrease in dose reduces its efficacy or not, and (ii) whether scorching occurs at lower doses of Esso Tree Spray Oil when used with different power equipment. The spray chemical, in different dilutions, was applied on a hot sunny day to a section of tea which was uniformly and heavily infested with red spider, and the results are shown in the table 1.

Table 1

Sprayer and rates used					
Knapsack		Fontan		Micronette	
l/ha	% mortality	l/ha	% mortality	l/ha	% mortality
12.5	90	6.25	86	6.25	80
6.25	87	3.125	82	3.125	80
3.125	82	1.5	82	1.5	68

There was no severe scorching with any of the doses used with the three different spraying machines. The Micronette caused moderate scorching at 6.25 l/ha, very slight at 3.125 l ha but no scorching was observed at 1.5 l/ha. There was moderate to slight scorching, when the Fontan was used at 6.25 l/ha and 3.125 l/ha respectively.

These results indicate that Esso Tree Spray Oil, applied with power sprayers (Fontan or Micronette), may safely and effectively be used at 3.125 l/ha even on a hot, sunny and dry day. Because of its low persistence, during the rains or in cloudy spells, it is preferable that a higher dose e.g. 6.25 l/ha should be used with all sprayers.

Combined spraying trials

Most of the acaricides and insecticides recommended for the control of tea pests are in use as single chemical spray against a single pest. But recently a new approach to the problem of pest control has been tried. The question was asked as to whether a combination of pests, e. g. thrips., red spider and scales, could be controlled by one single spray operation using a combination of recommended pesticides.

It is a well-known fact that bushes in Darjeeling are simultaneously attacked by thrips, scales and red spider. In the Terai, it was noticed that bushes were frequently attacked at the same time, by red spider and scarlet mite and in some cases scales were also located in the same area. In Assam, it is very common to find areas of tea bushes where red spider, scarlet and pink mites are simultaneously present and others where mites, thrips and Jassid occur simultaneously.

In view of this, trials were carried out in the Dooars, Terai, Darjeeling and Assam where different chemicals were mixed together at different quantities.

Joint Action of acaricides

Field Trial No. 1—A field trial was laid out in a section of tea where red spider, scarlet and pink mites were simultaneously present. The treatments were applied with a mist blower (Fontan). The combination of acaricides used and their rates of application were :-

a.	Ethion 4 E + Kelthane E. C.	at 0.625 l/ha + 0.625 l/ha	respectively
b.	„ „	at 0.312 l/ha + 0.312 l/ha	
c.	Tedion V-18 + Kelthane E.C.	at 0.625 l/ha + 0.625 l/ha	„
d.	„ „	at 0.312 l/ha + 0.312 l/ha	
e.	Kelthane + Akar	at 0.625 l/ha + 0.625 l/ha	„
f.	„ „	at 0.312 l/ha + 0.312 l/ha	„

The result was encouraging and it was found that mixtures of two acaricides such as Ethion and Kelthane, Tedion and Kelthane, Kelthane

and Akar when used at the rate of 0.312 l/ha of each were highly effective for the control of combined infestation of red spider, scarlet and pink mites.

It may thus be concluded that combination of two acaricides, when used at half the recommended rates of application for use by themselves in single sprays (i e. 1.250 l/ha), gave excellent control of red spider, scarlet and pink mites.

Field Trial No. 2—A similar trial was located in a estate in the Terai in a section where the bushes were simultaneously infested with red spider, scarlet and purple mites. The acaricide mixture used and their rates of application were :-

a.	Tedion +	Kelthane +	Rogor at 0.375 l ha	0.375 l ha +	1.25 l/ha respectively
b.	Tedion +	Kelthane	0.625 l ha +	0.625 l ha	,,

The results indicated that there was not much difference in effectiveness between the two mixtures of acaricides and both were equally effective.

So far the results of these two experiments are encouraging and they suggest that the effects of the joint action of two or three acaricides mixed together and used against a combined infestation of two or more mites can be effective and economical.

Joint action of acaricides and insecticides

In the foregoing text, the result of mixing two acaricides for control of mixed population of different mites has been discussed. But there are sections of tea where not only mites and mites are mixed but where mites and insects are frequently located at the same time.

Thus it was decided to try the effects of acaricides mixed with insecticides.

Field Trial 1

This trial was located in a section where there was a combined infestation of red spider, scarlet mite and scale insects. The treatments were applied with a knapsack sprayer and the acaricide insecticide mixtures used with their rates of application were :

a.	Tedion +	Kelthane +	Rogor at 0.75 l ha	0.75 l ha	2.50 l ha respectively
b.	Tedion +	Kelthane +	Rogor at 1.25 l ha +	1.25 l/ha +	1.25 l ha ,,

The result was encouraging and it was found that for the control of mixed infestation of red spider, scarlet mite and scales in a section of tea, a combined spray of Tedion, Kelthane, and Rogor at the lower dosage rates can be effectively used.

Field Trial 2

A similar trial was conducted in a section of tea where red spider, scarlet mite and thrips were present but no scales. The acaricide/insecticide mixtures were applied with a mist blower (Fontan) and their rates of application were :-

a Tedion + Kelthane + DDT at 0.375 l/ha + 0.375 l/ha + 1.250 l/ha respectively

b. Tedion + Kelthane + DDT + Rogor at 0.625 l/ha + 0.625 l/ha + 0.625 l/ha + 0.625 l/ha respectively.

The results showed that the combined spray of Tedion, Kelthane and DDT at the above doses, gave excellent control of all the pests. It is also concluded from the consideration of the cost of chemicals, that the first mixture is preferable to the second.

Insecticides

Looper caterpillar

Control of looper caterpillar *Biston suppressaria* Guen., has become a problem in tea. DDT at concentrations which kill the first or second instar larvae of looper are of no value against those which are in third, fourth and fifth instars. It is well-known that Endrin is a valuable insecticide for the control of looper caterpillar; it is highly insecticidal at low dosages, persistent and highly stable, but it has a very high mammalian toxicity. For this reason alone, although it is so efficient, it is not possible in general to recommend its use in tea in plucking but in case Endrin has to be used on tea in plucking, then at least two rounds have to be discarded While working on the residual contents of Endrin in tea it has been proved beyond doubt that Endrin leaves toxic residues beyond permissible limits even three weeks after spraying. The tolerance level allowed for Endrin is 0 (zero).

In view of this, it was thought worth while to try other insecticides of low mammalian toxicity against looper. A broad spectrum new insecticide Thiodan, having much lower toxicity (22 times less toxic than Endrin, was tried and compared with other chemicals of low mammalian toxicity.

The trial was conducted on mature tea in sections which were heavily infested with looper caterpillar and spray chemicals were applied at 2.5 l/ha with a mist blower (Fontan). It was noted that within 48 hours of spraying, Thiodan gave the best result in comparison with Mythyl parathion, Malathion or Rogor and its speed of action was excellent, killing 92 per cent of the population in the treated area. To be of real value for the control of looper caterpillar an insecticide must kill at least 90 per cent of the caterpillar in less than three days. One reason for this requirement is that a few large looper caterpillar will defoliate a tea bush if left undisturbed for even a few days thereby the number of plucking shoots are reduced. Another reason is that rain is frequent during the time looper caterpillars are most abundant and this may reduce the effectiveness of the insecticide by washing a part of it off the leaves. The fact that Thiodan gives a high kill in a short time may make it especially valuable for the control of this pest.

After seven days at the end of the experiment, Thiodan still proved the best and had by then killed 100 per cent of the population.

Helopeltis theivora

New insecticides of low mammalian toxicity - Thiodan 35 E. C., Anthio, Birlane and Ortho Dibrom were tried this year in comparison with the standard insecticides DDT and Dieldrin for the control of *Helopeltis theivora*.

The trial was conducted in the Dooars on mature tea in a section which was moderately infested with *H. theivora* and the chemicals were sprayed at 1.25 l/ha with a Micronette.

Thiodan and Birlane applied at 1.25 l/ha with Micronette were found to be very good for the control of *Helopeltis theivora* in comparison with DDT.

Fungicides

Blister blight

A field trial was laid out in Darjeeling in a section where infestation of blister blight had occurred every year on bushes which were pruned in the cold weather of 1966. Altogether three rounds of spraying were given at intervals of seven days.

The results show that the copper formulation, Cuprocol and organic fungicide RH-90 at the rate of 2.5 kg/l/ha were superior to Foroplant, Captan, Orthodifolatan and Brestan. It was also observed that a very satisfactory level of control was obtained after three rounds of application, and almost complete protection from blister blight attack was afforded until the end of the season.

Nematicides

Root knot Nematodes

Nemagon and EDB granular formulation have proved effective against root-knot nematodes (Ann. Rep. 1966). A new formulation Nemafos granular, an organophosphate, was received this year for comparing its efficacy against Nemagon as a prophylactic measure (pre-sowing soil application) and a field trial was laid out in Tocklai. The granular EDB at 483 kg/ha and two doses of Nemafos granular at 4.5 kg and 9 kg respectively were tried.

Analysis of the results showed that the percentage of plants free from root-knot was significantly higher in Nemagon and EDB granular treated plots than in the untreated control and also root-knot indices were significantly lower in the Nemagon and EDB granular treated plots. The number of seedlings which reached plantable size were significantly greater in Nemagon treated plots than in EDB granular treated plots. There was no significant difference between the Nemafos granular treated plots and the control plots in respect of root-knot infestation, root-knot indices and usable transplants.

Taints of Made Tea due to Pesticides

Metasystox, Morestan, Mesurol, Anthio, Hexakel, Hexamition, Thiodan Captan, RH-90, Acrex, Birlane, Rospin, A 2529, Ortho Dibrom, Methyl Parathion, Micothion (Trithion), C 8514 and Sumithion were tested to find out whether they taint made tea when sprayed at normal rates. None of the chemicals imparted any taint to made tea.

Residues

Field trials were conducted during dry and wet weather conditions to evaluate residues of Acrex, Chlorobenzilate, Ropspin and A 2529. Similar trials were carried out during wet weather with Trithion and Thiodan.

Certification of Pesticides and Herbicides

During the year eight new products were received for official testing. Certificate of approval for 17 products were issued and 17 Certificates were renewed. One interim Certificate was also issued.

BIOCHEMISTRY DEPARTMENT

RESEARCH AND EXPERIMENT

Manufacturing aid

Experiments relating to the improvement of the overall commercial value of tea by using a manufacturing aid continued throughout the whole season. Teas were manufactured with and without the aid from two *jats*, Betjan and Khorijan by both C. T. C. and Orthodox methods. The teas were tasted by Tocklai and London tasters.

Both the sets of tasters preferred the treated teas and were of opinion that there had been a definite overall improvement although the degree of preferences differed between tasters.

The keeping qualities of these teas are being studied by analysing them periodically.

More experimentation will, however, be necessary before this new process can be standardised for commercial use.

Chemical Constituents of tea leaf

Aroma components :

The investigation into the aroma components of tea leaves was continued.

The aroma is a complex mixture of several chemical compounds such as alcohols, aldehydes, ketones, esters, terpenes etc. Aroma cannot be perceived in tea leaves growing on the bushes, but as one steps into the fermenting room of a tea factory, the aroma of tea is apparent. The aroma is developed during the processing of the tea leaf when chemical transformations of many of the constituents of the leaf are involved. This initiation of the chemical changes is accelerated in the presence of specific enzyme systems.

Attempts were made to isolate all or parts of the tea aroma-complex by treating partially processed tea leaf and tea made from Betjan *jat* with petroleum spirit for over two weeks. The extracts were filtered through cotton wool and dried over anhydrous sodium sulphate. The solvents were then distilled off at as low a temperature as possible in order to minimise the loss of the volatile components and thereby arrive at concentrate rich in aroma.

The aroma rich concentrates were subjected to column chromatography using 'Brockman' alumina as adsorbent. The chromatographs were then developed with petroleum spirit and benzene using the two, either separately or in mixture. Out of over 100 fractions each of 75 ml, a dozen or more emitted very pleasant odours.

In earlier experiments, fresh leaf from the same source was finely minced and by subjecting it to the above procedure, an amorphous compound having melting point 85-87° C was isolated. The sample was analysed in the National Chemical Laboratory, Poona for its molecular weight (Rust method) and infra-red spectra. The molecular weight of the compound was 356. Infra-red spectra showed that the compound contained an alcoholic group.

Distribution of polyphenols in different parts of the tea shoot

The quantitative distribution of the three major and important polyphenols, (−)− epigallocatechin (EGC), (−)− epigallocatechin gallate (EGCG) and (−)- epicatechin gallate (ECG) along with theogallin (TG) was studied in the different components of tea shoots containing three leaves and the growing bud. Tea shoots were collected from a mature seed grown plot at Tocklai, from the early part of May to early August and the dried components were examined for their phenolic contents, using the spectrophotometric method of estimation. The nature of distribution of the polyphenols is presented in Table 1, which gives the average figures with their standard errors, obtained from four repeats.

Table 1. Concentration of polyphenols (% on dry weight) in the different parts of tea shoot ± SE (standard error)

Source : A mature seed grown plot at Tocklai

Sample	EGC	EGCG	ECG	TG	Total
Bud	6.15±0.96	7.05±0.76	2.38±0.13	1.64±0.31	17.02
1st leaf	6.76±0.31	7.37±0.26	2.00±0.22	1.25±0.29	17.38
2nd leaf	6.12±0.33	5.41±0.36	1.62±0.11	0.95±0.09	14.10
3rd leaf	6.12±0.63	5.44±0.42	1.45±0.09	0.91±0.05	13.92
Stem	3.91±0.95	1.63±0.68	0.74±0.14	0.75±0.07	7.03
Weighted means for whole shoot	5.89	5.42	1.64	1.07	14.02

The difference in the phenolic contents of the bud and the first leaf is negligible and so also the differences between the second and the

third leaves. The stem, as a whole, is poor in comparison to the other parts of the shoot.

Enzyme activity of banjhi and growing shoots

A preliminary study of banjhi and growing shoots in respect of their enzyme activity and total oxygen uptake revealed little difference between the two types. A more detailed study of this aspect in the two types of shoots from various sources is considered imperative to arrive at a comprehensive picture.

Chemical changes during drying

Tea shoots while still on the bush are undergoing two sets of chemical reactions known as anabolism (building up process) and catabolism (disruptive process). As soon as the shoot is plucked, there is a change-over in the chain of chemical reactions and catabolism dominates. In addition to this, another set of reactions starts instantaneously at the stem ends of the shoot (and also at other sites of damage, if any) where the cells have been exposed. The dark browning at the end of the stem is caused by such reactions, which involve mainly the oxidation of the colourless polyphenols to coloured products. The chemical changes occurring (breaking down of proteins to amino acids and increase in caffeine) in the shoots during withering have already been established. The nature of chemical reactions during the rolling process in which the leaf cells are damaged, are similar to those that take place at the stem ends just on plucking.

In the manufacture of tea, the chemical reactions initiated by rolling the leaf are allowed to continue in the fermentation stage until the leaf acquires a copper-brown colour and emits the characteristic aroma of tea. Though this stage is considered to be the completion of the necessary chemical transformations (as judged by the eyes and the nose) of the leaf constituents for the production of good tea, and as such, the fermented leaf is immediately transferred to the drying machine, it is to be ascertained if in fact, the chemical reactions stop at this stage. Apparently, the object of drying the fermented leaf is to remove the moisture and reduce the bulk for storing and packing. This, however, is only the physical aspect of drying. The second idea is that, by drying, the enzymes present in the leaf are inactivated at the high temperature and the enzymatic reactions are stopped.

When the fermented leaf is put into the drier, the leaf takes a little time to attain the full temperature at which the fermentation is stopped. It is therefore, most likely that the enzymatic reactions continue until the enzymes are inactivated. Non-enzymatic reactions, however, go on upto the

end of drying and even afterwards. It was, therefore, intended to study the changes of the chemical constituents of the processed tea leaf at different stages of drying.

Tea shoots from clones 20/23/1 and 19/29 13 were collected on three occasions between late July and late October. The withered leaf was rolled, passed through a C. T. C. machine twice, and then fermented. Just after the fermentation a sample was collected which was used as the control. The rest of the fermented leaf was dried and samples were collected after the 10th, 20th and 35th minutes (fully dried) of drying. All the samples were analysed for the following constituents :

(1) Moisture
(2) Water soluble solids
(3) Total oxidisables (Lowenthal)
(4) Water soluble nitrogen
(5) Caffeine nitrogen
(6) Protein nitrogen
(7) Amino acid nitrogen
(8) Total nitrogen
(9) Caffeine
(10) Creaming index
(11) Theaflavins
(12) Thearubigins

The individual polyphenols were also estimated by the spectrophotometric method after their separation on a two-way paper chromatogram of the methanolic extracts of the samples. Three repeat runs for each of the clones were made. Results are presented in Table 2.

One of the practical difficulties faced in this experiment was the collection of the samples at different periods of drying since the degree of drying was not the same at the lower and the upper surfaces of the fermented leaf spread in the drying machine. Thus sampling errors crept in, especially in the first two samples (10th & 20th min). During the time lapse between the collection of the samples and the start of their analyses, throughout which the samples remained at a higher temperature, it was most likely that chemical transformation of the constituents in the partially dried samples continued. This was another setback in getting uniform results in the analyses of the samples.

The figures in the table indicate that apart from the obvious loss in moisture, the water soluble solids and water soluble nitrogen decreased and the creaming index increased with the progress of drying in the case of clone 20/23/1. Other minor losses were in caffeine nitrogen, amino acid nitrogen and the total polyphenols (Lowenthal). The polyphenols, (-) - epigallocatechin gallate (EGCG), (-) - epicatechin gallate (ECG) and theogallin (TG), present at the start (0 min), decreased a little at the end of the drying, indicating that the transformation of these phenols continued during drying.

The behaviour of clone 19/29/13 was not similar to clone 20/23/1. Unlike clone 20/23/1, the creaming index of clone 19/29/13 decreased with the time of drying This proved one of the inherent basic differences of the leaves of the two clones. It, therefore, warrants further experimentation on this project with leaves from various *jats* and clones for more detailed study.

MISCELLANEOUS EXPERIMENTS

Use of Aluminium Rollers

Tea samples manufactured by using aluminium rollers were examined to see if their aluminium content increased beyond the normal concentration. No such increase was detected on analysis of the samples.

Tea Fibre Separation

Legg cut tea samples, treated with a certain liquid for the separation of fibres, were analysed for their fibre content and their major chemical constituents. It was apparent from the analytical results that only a little separation of fibre was achieved.

ADVISORY

Testing of tea samples

Altogether 393 samples were tested during the year of which 20 were instant teas.

Moisture Meters

20 moisture meters from various tea estates were adjusted and calibrated during the year.

MEETINGS

The Biochemist attended the meetings of the Scientific Committees of Darjeeling and Cachar areas and apprised them of C 5 project and the nature of other work.

Meetings of the Agricultural and Food Products Division Council (AFDC) and Tea Sectional Committee (AFDC : 16) of Indian Standards Institution, held in New Delhi, were attended by the Biochemist. The convention of Biological Chemists' (India), held in Bangalore, was also attended.

MANUFACTURING ADVISORY & TEA TASTING DEPARTMENT

Fineness of Plucking

It is a common experience that finer plucking produces better tea, but very little is known in fact about the economics of the situation. An increased price for tea cannot be considered in isolation and it must be balanced against any potential loss in crop at the field or overall increase in cost of production. In an attempt to collect data towards solving this equation, teas were made from strictly one leaf and a bud, strictly two leaves and a bud and shoots plucked as in normal rounds which contained about 75% fine (i.e. upto the 2nd leaf) leaf by weight. Manufacture was conducted during the rains period only and the tasting results showed that the tea made from one leaf and a bud were worth about Rs. 1.50 per kg more than the normally plucked leaf and the tea made from two leaves and a bud Rs. 0.60 per kg. more. The bud and the first leaf makes much better tea than the second leaf, stem and banji shoots.

Another part of this investigation was designed by the Senior Botanist whereby separate components of shoots were manufactured for him and the resultant teas valued. Results are given in his Report.

Although some first quantitative data has been obtained during the year a lot remains to be done. During the next year it is intended to manufacture samples of different leaf qualities throughout the year, not only during the rains and Senior Agriculturist has started an experiment to observe the effects on yield of plucking on very short to normal rounds. Tea will be made from these plots.

Leaf Carriage

Careless leaf handling during transporting leaf from the field to the factory can adversely affect the cup characters of the made tea. Teas made from undamaged, partly damaged and severely damaged leaf were assessed for cup quality and the assessment showed that if the leaf is severely damaged then the loss can be as much as Rs. 0.60 per kg, and if the leaf is only partly damaged then the loss can be as much as Rs. 0.40 per kg, compared to the undamaged leaf. Again in the case of clones the loss in value due to leaf damage can be. much higher and as much as Rs. 1.50 per kg for severe damage and Re 1.00 per kg for partly damaged compared to the undamaged leaf. Work is going on to find out exactly how and when the majority of leaf damage takes place.

Roller Charge

The effect of roller charge on the cup characters of made tea and the need to vary roller charge depending on the wither are not always realised. Experiments carried out on these factors showed that with a higher wither

it is necessary to increase the roller charge and with a lower wither, to decrease the charge. Overloading as well as underloading of rollers equally affects liquors adversely. These observations were made on orthodox manufacture in the plains of N. E. India.

Effect of roller charge on the cup characters of C. T. C. tea is being investigated. Preliminary observations tend to show that overloading and underloading of rollers can adversely affect the cup characters of C.T. C. teas as well. However, more work is needed before arriving at any firm conclusions.

Period of drying of C. T. C. and Orthodox teas

Dual manufacture is very popular in N. E. India at present, whereby the fines are used for orthodox manufacture and the remainder for C. T. C. With the introduction of dual manufacture the question of optimum throughput time through the dryer in the first fire for C. T. C. and Orthodox teas has to be considered. Should the Orthodox tea be dried in the same manner as C. T. C. tea ?

The important point which will govern the period of drying is the rate of loss of moisture and the data obtained so far show that the rate of loss of moisture in the case of Orthodox tea is much lower than for C. T. C. tea. So to be able to dry efficiently, which is one of the most important factors that governs the liquor characters of made tea, Orthodox tea should be dried at a much slower rate than C. T. C. tea. In other words Orthodox tea should be dried at a comparatively lower temperature with comparatively longer throughput time through the driers than the C. T. C. tea.

Unpruned Tea

Although longer cycles, including unpruned tea, increase yield, doubts are still held as to the quality of the made tea. An attempt was made to obtain data for teas made from unpruned tea by C T. C. as well as Orthodox methods of manufacture, From the end of December 1967 to the end of February 1968 such teas were sent to three Blenders in the U. K. and also to one internal Buyer in India, and one internal Blender and a Broker in Calcutta for their opinions. London tasters found the teas unsuitable for use in their blends while some of the Calcutta tasters thought that these teas could be used at a price of about Rs. 2.50 to Rs. 3.00 per kg. However, the teas made from the early part of March improved a little and had a standard somewhat similar to rains, non-descriptive teas.

So far, observations on the commercial teas made in Assam from totally unpruned bushes show that in the case of Orthodox manufacture there is very little tip and in cup, both Orthodox and C. T. C. teas have hardly

any pronounced quality during the second flush. The difference in value of C. T. C. teas made from pruned bushes and continuously plucked bushes (i. e. not pruned nor skiffed) is in the region of Rs. 4.00 to Rs. 6.00 per kg during the second flush period, the pruned teas being always superior with much finer quality.

Teas made from these unpruned bushes are not suitable for the export market and will most probably have to be consumed in the internal market.

As in the case of fineness of plucking, mentioned earlier in this report, the true end point can only be expressed by profits. The decrease in price per kg of teas made from untouched bushes must be balanced against the increase yield and the reduction in overall cost of production.

Manufacture and assessment of leaf samples for other Departments

Leaf samples from experiments on plucking, pruning and manuring were manufactured and tasted according to designs given by the Statistical Department for the Agricultural and Advisory Departments Leaf samples were also manufactured and tasted for the Botany Department and some very fine quality clones were discovered. Teas made by various machines being developed by the Engineering Development Department were assessed and the teas made with the Fermenting-cum-Drying machine in a commercial estate were found to be inferior to the normal manufacture practically throughout the rains. But with the onset of the cold weather the teas from this machine improved considerably and were in most cases superior to the normal manufacture. The teas made by the RV C. T. C. method with the cone fitted to the rotorvane were consistently superior to the teas made by RV C. T. C. method without the cone attachment. Considerable improvement of the cup characters of the tea made with the manufacturing aid by the Biochemistry Department was observed.

Advisory Work

Advice on manufacturing problems is first given as far as possible, by tasting at Tocklai and at different group tasting sessions held in different areas. This procedure has had to be evolved as it is not possible for one man to cope with a total of 563 estate factories and also the internal work of the Station. Therefore preliminary screening for obvious faults is done by tasting and thereafter factories are visited only if it is absolutely necessary. This is admittedly not a very satisfactory procedure, and the Department is being strengthened as quickly as possible. Mr. M. R. Patel, Second Tea Taster arrived at the end of this year.

This season 14 tasting sessions were held throughout the plains areas. Advice by actual visits to the factory had to be confined to only 114 estates, although the need was much more.

It is gratifying to note that estates which followed our advice meticulously, realised higher prices varying from anything between 40 paise per kg to Rs. 2.00 per kg; the proportionate increase in price being more in case of the poor quality estates.

The advice given was mostly on correct programming and on the proper use of the different machines. Without the addition of any more machinery, there is still room for improving quality in quite an appreciable number of factories in N. E. India by just paying more attention to the basic details involved.

Generally, withering facilities are still inadequate in most factories. Troughs have been installed and being installed in many factories but in most cases their capacity is far too low for the crop harvested. Thus for example, three standard sized troughs 48" × 6"; for a crop of 3,73,242 kg. (10,000 mds are more of a hinderance than a help when it comes to smooth programming.

To get the maximum theoretical benefit it would be necessary to artificially wither 100% per cent of the maximum expected crop on a peak day but in reality this is probably not economical. Therefore a reasonable lower aim is not less than 50% of a peak day the rest being withered naturally. Anything above this will be beneficial providing it lends itself to smooth programming.

In C.T.C. manufacture our experience during the year was that insufficient attention was paid to the conditioning of the leaf prior to cutting in the C. T. C. machines. There is a great need for more attention to be given to roller charges and the speed of the rollers in Roll C. T. C. manufacture. Excessive pressure is too often applied by bad adjustment of the end plate of the rotorvane and too little attention is given to the feeding of the rotorvane in RV C. T. C. manufacture.

The standard of drying has improved during the last few years, but there is still room for more improvement. The arrangements for allowing the exhaust air from the driers to escape freely from the drying room are not adequate in many factories. For example, in one C. T. C. factory the output of the drier was increased from 75 to 112 kg. (2 mds to 3 mds) per hour simply by making an opening in the roof large enough for the exhaust air to escape freely from the drying room.

Tea Tasting :

Samples from estate selected clones were tasted regularly throughout the year and assessments given. Drying of clonal samples is still very poor and the main reason is that the small samples are not dried long enough.

During the season 3,461 experimental samples from Tocklai, 5,795 samples from estates for advising on manufacture and 8,251 clonal samples from estates were tasted.

Refresher Course

The Manufacturing Adviser & Tea Taster was in the U. K. for three months for a refresher course. He visited Kenya on his way back to Tocklai.

ENGINEERING DEVELOPMENT DEPARTMENT

RESEARCH AND EXPERIMENT

Withering

A simple three stepped trough in a prototype form was fabricated and attached to the discharge end of the prototype withering tunnel at the Pilot Factory, with a view to improving the performance of uni-directional troughs of standard design. The results obtained from this prototype trough were found to be extremely encouraging in that the variation of wither in the three steps was within ± 1.5%. The steps in the prototype were 244 cm (8′) long, and the depth of the air duct below the sections were 94 cm (3′–1″), 66 cm (2′–2″) and 3′8 cm (15′) respectively, beginning from the inlet end of the sir duct.

Rolling

Continuous Green Leaf Processing Machines

i) Prototype Rotary Continuous Roller, Disc Type.

(a) The 76 cm (30″) diameter prototype Disc Roller was temporarily installed at Kotalgoorie Tea Factory to be tried out in competition with their standard roller/ C. T. C. manufacture. The treatments were as follows :-

Treatment A–30 mts normal roll/3 cuts C. T. C. control treatment.
Treatment B–2 passes through Disc 3 cuts C.T.C.
Treatment C–10 mts normal roll/1 pass through Disc 3 cuts C.T.C.
Treatment D–15 mts normal roll/1 pass through Disc/3 cuts C. T. C.

The average nominal valuations of 11 repeats of these experimental teas according to the Manufacturing Adviser and Tea Taster at Tocklai were as follows :-

Treatment A—Rs. 5.39 Control
Treatment B—Rs. 5.78
Treatment C—Rs. 5.52
Treatment D—Rs. 5.89

All the treatments where the Disc Roller was used showed better valuations than the control, chiefly due to the improved quality and strength of the teas.

This 76 cm (30′) diameter machine was then sent to Ging T. E. in Darjeeling for comparative manufacturing trials against orthodox rollers towards the end of the season in October 1967. Full trials will take place during the 1968 season.

(b) A 122 cm (48") diameter commercial prototype Disc Roller was fabricated during the early part of the 1967 manufacturing season. The unit was mounted on a pedastal made from structural steel sections. It was in operation at Tocklai during the 1967 manufacturing season with minor modification and alterations from time to time. The machine had the feed screw running at 48 rpm while the disc was running at 24 rpm and at those speeds, the capacity of the machine was found to be 1130 Kg (2600 lbs) of withered leaf per hour. The liquors and appearance of dry leaf was comparable to those from orthodox rollers, but, the colour of the tips was considered to be too pale by the tea tasters. This aspect of improving the colour of the tips was looked into and modifications made during the off season which should improve leaf against leaf action. It will be possible to study the outcome of these measures early in the 1968 manufacturing season.

(c) Miniature Disc Roller

At the instance of the Area Scientific Committee of the South Bank, West, work was taken in hand to provide the Industry with a small mechanical device which can condition leaf for miniature C. T. C. machines normally used for clonal selection work. A miniature Disc Roller was fabricated and teas processed from leaf conditioned in this device for manufacture in miniature C. T. C. machines were compared against those from the normal Pizey/C. T. C. method of manufacture.

After a few trials with the first machine, a design was evolved which produced results far superior to the standard Pizey/C. T. C. method of manufacture. The Tocklai Manufacturing Adviser and Tea Taster's report on a series of such comparative experimental samples can be summarised as follows :—

Table I.

Comparative assessment of teas from Two Different Methods of Miniature Manufacture

	Method of Manufacture	
	Miniature Disc C.T.C.	Pizey/C. T. C.
Strength	Good	Fairly good
Quality	Good	Fairly Good
Valuation	7 10	6,50

Tenders for commercial manufacture of the Disc Rollers (the commercial sized one as well as the miniature version) were being invited from Tea Machinery Manufacturers by the Tea Research Association, Calcutta at the time of writing this report.

(ii) Vertical Type Continuous Roller

As stated in our Annual Report for 1966, the 38 cm (15") diameter vertical type continuous roller was fabricated at Tocklai during the early part of 1967 manufacturing season and was operated from time to time in competition with other continuous leaf processing machines under development at the Pilot Factory. Its main features are very generous clearance between the vanes and the resistor pins and vertical cylinder which is split along its mid-line to make cleaning easier. The original smaller 30 cm (12") diameter machine was remodelled to induce more cutting action.

Both these vertical machines were operated during the 1967 season and samples tasted by the Tea Taster at Tocklai. The general trend in all the reports on these teas were as follows :—

"*Leaf :* These teas are somewhat like the Disc Roller samples but they have less make and are a little blacker.

Infused leaf Fairly bright.

Liquors Liquors are much inferior to the Disc Roller samples. They are harsh on the palate with fair brightness and briskness. The 30.5 cm (12") diameter machine is harsher still in cup when compared with the 38 cm (15") diameter machine."

It would appear from the trend of the tasting remarks that these machines require further development and study before they can produce teas of acceptable standard on their own. The machines as developed upto the year under report, being all open top machines with a tendency to produce more small leaf, may prove to be suitable for use in conjunction with legg-cut manufacture where aeration of cut-leaf during rolling is considered to be a desirable feature. Efforts were, therefore, being made to send the 38 cm (15") diameter machine to a Dooars factory to try out its potentialities as a processing machine for Legg-cut type of manufacture during 1968.

(iii) Rotorvane

(a) Cone attachment with an adjustable sleeve for 38 cm (15") Rotorvane.

Manufacturing trials with the cone attachment revolving within an adjustable sleeve at the discharge end of a 38 cm (15') rotorvane under commercial conditions of manufacture were initiated at Tengpani T. E., Assam, with the co-operation of the management of that estate. The trend of results from this experiment was the same as reported in the 1966 Annual Report, in that the teas processed through the rotorvane with the cone attachment were preferred to roll C.T.C. or normal Rotorvane C. T. C. teas due to improved brightness and briskness of the liquors. Reports on teas from the Central Dooars Tea Co's Rungamatee T. E., where an experimental cone was in operation from last year, continued to be satisfactory. The Port Engineering Works had been asked to submit their quotations for commercial manufacture of this attachment to the Tea Research Association with the expectation that the cone attachment for the Rotorvane would be available for commercial use during the 1968 manufacturing season.

(b) Experimental 38 cm (15") diameter Aluminium Rotorvane

This machine fabricated by the Port Engineering Works and sent to Tocklai for trial in the 1966 manufacturing season was installed at Kamalpur T. E. and as reported in the 1966 Annual Report but the vane segments were found to be mechanically weak. This trial was continued this year at Kamalpur with a new set of aluminium alloy vane segments of a different composition specially manufactured by the Port Engineering Works. However, under the strain of the leaf load, one vane sheared at its root and the broken vane damaged the cylinder-lining of aluminium fitted inside the cast iron barrel. Finally, the broken vane was also responsible for tearing off four other vanes partially or wholly from their respective hubs.

Examination of the rotor parts indicated that after two season's working, the thrust face of the feed worm had worn off to razor sharpness at its discharge end.

In view of the above, it was decided to discontinue the experiment until a more suitable and mechanically tough aluminium alloy can be procured to replace the immensely suitable, but imported, gun metal, which has been the standard metal for the components of the rotorvane so far.

(c) 20 cm (8") Prototype Rotorvane

The experiment with the short 20 cm (8") Rotorvane was continued with one and two vane segments together with the cone attachment and

sleeve, at the discharge end of the machine. The processing action of this short rotorvane has been improved further by modifications to the sleeve and the rotor. Comparative manufacture of one and two vaned rotor with a cone, produced teas which were generally commented on by the Tocklai Tea Taster in the following manner.

"8" Rotorvane Samples one vane- vs- two vanes

Leaf : In leaf I give slight preference to the one vane Rv. sample being a little bolder in size. The coarse mal from this experiment with the one vaned machine contains less fibre and is preferred.

Infused leaf : Green.

Liquors : Very green and harsh. The two vane Rv. samples are little mellower than the one vaned sample and as such are preferred."

The experiment with this machine will be continued

(iv) Tocklai Continuous Roller :

No significant progress on the fabrication on the Mark II Tocklai Continuous Roller was made during the year by the Britannia Engineering Co., who, however, assured us that a prototype Mark II T. C. R. would be made available to Tocklai for trials during the early part of the 1968 manufacturing season.

Fermentation : Continuous Machine

5′ (162 cm) Commercial Prototype Fermenting cum Drying Machine.

As proposed in the Annual Report for the year 1966. the 5′ (152 cm) continuous fermenting cum drying machine was re-positioned at Duklingia Tea factory by constructing an additional lean-to shed for the direct oil fired air-heater. Two independent tanks to supply T. D. and L. D. oil to this heater were also installed.

The fermenting chamber was positioned on the floor ahead of the drying chamber in an in-line arrangement.

Trials with the machine arranged in this new way showed improved conditions for fermentation. However, the major item of heat input into the fermenting chamber is the residual heat of the trays returning empty from the drier. The cooling time that could be afforded for the trays between drier mouth and entry to the fermenting chamber, was only about six minutes at the maximum and that is inside the drying room of the factory where the conditions become increasingly hotter with the progress of the day's manufacture.

Lack of funds for purchasing a suitable cooling unit compelled us to try out methods other than the ideal, and as a consequence the results achieved were far from satisfactory. The expedient tried out was sucking in comparatively cooler ambient air through a humidifier and exhusting a part of the air that passed through the chamber through adjustable grills at the front end of the fermenting chamber. The average conditions under which the machine worked during the 1967 season are shown in Table 2.

Table- 2

Month	Average temperature inside the fermenting machine in °C. Figures within brackets are in °F.		Average temperature of the drying room in °C. Figures within brackets are in °F.		No. of comparative samples tasted at Tocklai	No. of times continuously fermented teas were preferred.
	D.B.	**W.B.**	**D.B.**	**W.B.**		
July	41.6 (107)	40.6 (105)	28.6 83.5	26.6 80)	none	none
August	40.0 (104)	37.6 (99.7)	35.5 (95.8)	30.5 (87)	22	11
September	37.5 (99.6)	33.9 (93)	35.0 (95)	29 8 (85.7)	13	7
October	33.4 (92.1)	29.8 (85.7)	30.1 (86.2)	25.4 (77.6)	18	9
November	33.7 (92.7)	31.7 (89.0)	27.5 (81.5)	22.2 (72.0)	24	17

With the advent of the cooler weather, the ambient temperatures dropped considerably and hence the cooling contions for the trays enabled us to revert to a hundred percent recirculation of air inside the fermenting chamber. Complete recirculation, which is the design target, thus being achieved, the samples of teas fermented and dried in this machine during the months of late October and November, 1967, were considered to be showing marked improvement by the Tocklai Taster. Throughout last season it was found that the samples drawn at the beginning of the day

are better than those drawn later in the day indicating the urgent need for improvement in the temperature conditions inside the fermenting chamber

The experiment is proposed to be continued during 1968 using a 5 ton air-conditioner unit which should enable us to achieve the desired degree of control over the temperature and humidity conditions inside the fermenting chamber. The data collected from the proposed experiment should be of considerable value in designing a commercial version of the Continuous Fermenting machine.

Driers

The Commercial Prototype of the Tocklai Continuous Tray Tea Drier at Hunwal factory was brought up to the standard of the commercial version of the machine by replacing the two side plates at the front end of the drying chamber, thereby reducing the free space between the leading edge of the trays and the front plate of the chamber separating the drying chamber proper from the enclosed feed chamber. The performance of the machine after this modification was found to be very much better, and outputs of over 200 Kg. (440 lbs.) made tea per hour from C. T. C. type of manufacture had been reported with a fuel consumption of approximately 0.227 litres per Kg of made tea (1.75 gallons/md of made tea). The inlet and exhaust conditions remained at 93.5°C (200°F) and 43.5 °C (110°F) respectively.

Moisture Content of Green Leaf

The project had to be held in abeyance due to lack of equipment and resignation of the Second Research Engineer.

Direct Firing

Comparative assessment of teas from direct and indirectly fired teas were taken in hand in collaboration with commercial estates having facilities for both types of firing in driers of similar make, to study the differences, if any, between these two types of firing under commercial conditions of manufacture.

With regard to the quality of T. D. Oils used for direct firing of teas, the results of the analysis of sample of T. D. Oil sent to Alipur Test House and the Indian Institute of Petroleum are quoted as follows

Alipur Test House

	Samples drawn from				Requirement of I.S.S. 1593-1960-Grade LV.
	Kakajan	Hunwal	Duklingia	Cinnamara	
1. Appearance	Dark coloured viscous oils free from visible impurities				
2. Closed flash point (P. M.)	above 66°C	above 66°C	above 66°C	above 66°C	above 66°C
3. Kinematic Viscosity at 122°F (50°C)	10.5 Centi stokes	11.2 Centi stokes	9.4 Centi stokes	10.8 Centi stokes	80 Centi stokes max.
4. Gross Calorific value Cal/gm.	10580	10580	10635	10380	not limited.
5. Water content Dean & Stark method)	Trace	Trace	Trace	Trace	1% max
6. Ash % by wt.	0.017	0.017	0.015	0.016	0.1 max
7. Sediment	Practically nil	Practically nil	Practically nil	Practically nil	0.25% max.
8. Inorganic acidity	Nil	Nil	Nil	Nil	Nil

Remarks : "All the four samples satisfy the requirements of clause 4 of LV grade fuel oil to Indian Standard Specification No. 1593-1960."

Analysis of Tea Drier Oil Samples

	Cinna-mara	Duk-lingia	Hunwal	Kakajan
Kinematic viscosity at 100°C, cs.	3.14	3.20	3.35	3.09
Flash point, PM CC,°C	85	81	86	90
Copper strip corrosion for 3 hours at 100°C	1b	1b	1b	1b
Water content, % Volume	0.45	0.25	0.30	0.40
Ash % Weight	0.02	0.017	0.025	0.025
Inorganic acidity	Nil	Nil	Nil	Nil
Sulphur % by wt.	0.11	0.09	0.16	0.15
Sediment % by wt.	0.016	0.007	0.009	0.017

These studies on direct firing of tea will be continued.

Plucking Machine

It was generally agreed and realised that the Mechanical Tea Harvester, as developed at Tocklai in the late fifties could only be brought into use in gently undulating grounds and that too in a limited scale in mature-teas, as a comparatively clear passage has to be made through the tea bushes to allow movement of the wheeled vehicle; realignment of drains and shade trees would have to be done on a large scale to cater for its economic use. Furthermore approximately 75 per cent of the tea growing areas in N.E. India would preclude its use because of the nature, topography and shape of the planted areas. In view of the above, the development of the large self propelled harvesting machine was placed low down in the current Programme of Work.

It was, however, thought that there is scope for the development of a small manual aid to plucking to assist pluckers to harvest larger areas of tea in a given length of time than they can do by hand alone. With this aim, work was taken in hand to modify and improve a basic patented idea of a prior Indian Patent . Application for its patent coverage were then filed in several tea growing countries and several of these manual devices were fabricated at Tocklai and distributed to some commercial estates in N. E. India for trial and report. A trial was also laid out at Borbhetta to compare the relative efficiency of the manually operated shear harvesters

(as widely used in South India) and the Tocklai Manual Plucking Aid. The results from trials in the commercial estates are awaited.

Borbhetta's preliminary report indicates that the rate of plucking with the manual aid is 1.8 times faster than hand plucking, while the shear harvester is approximately twice as fast. But in the quality of leaf harvested, the shear harvester brings in 2 to 3 times the weight of damaged leaf in comparison with the Tocklai manual plucking aid at its present state of development.

Efforts were being made towards the end of the last manufacturing season to reduce the weight of this aid still further by substituting components of moulded plastic wherever possible. The experiment and trials with the device will be continued.

ADVISORY

Touring : The Senior Research Engineer attended three meetings of the Engineering and Technical Sub-Committee, two in Calcutta and one at Tocklai. He attended one meeting each of the Area Scientific Committees of Cachar, Dooars, Darjeeling, North Bank, East and West, South Bank East and West. He was a member of the delegation led by the Director to the U. P. A. S. I. Scientific Department. Whilst in Calcutta he paid visits to Britannia Engineering Co. and Port Engineering Works on three occasions. Advisory visits were paid to twenty four estates.

STATISTICS DEPARTMENT

During the year, the Department extended intensive co-operation and help in solving more than thirtyfive statistical problems encountered by research workers of different Departments of the Station in relation to experiments with agriculture, biochemistry, manufacturing and tasting of tea samples. Consequently, to meet these specialised requirements, appropriate statistical designs such as Balanced Incomplete Blocks, Cyclic Partially Balanced Incomplete Blocks and other non-routine measures had to be introduced. As in the previous year, these designs were found to be more efficient than simple designs because they have provisions for controlling more sources of experimental errors. For example, prior to 1966, it was not possible to differentiate with certainty teas manufactured from manurial plots in terms of valuation, whereas with the introduction of these new designs, the differences between manurial treatments can be more accurately tested by taking into account the differences between roller hoods and the effects of time lag on the treatments due to batch manufacture when the number of treatments exceeds the number of hoods. These measures have reduced experimental errors considerably and thereby increased the efficiency of experimentation. Increasing accuracy was also achieved in the Taster's method of scoring as no more than four samples were required to be tasted at any single time.

As a result, research workers of various Departments could draw valid conclusions on those problems which are of prime importance to the Industry such as selection of clones, manuring, other field management practices, manufacturing methods and so on.

Statistical Study of the Chemistry of Tea

In addition to the above, the complete statistical aspects of the project C5 of the Biochemistry Department (Tocklai Annual Rep., 1966, page 118) was taken up during the year to study the following points :

i) the effects of chemical factors on Valuation and the five liquor characters, Quality, Colour, Strength, Brightness and Briskness,

(ii the relationships between Valuation and the five liquor characters, and

(iii) the relationships between Quality and the other four liquor characters,

with the following main objectives in view :

(a) to provide guide lines for improving the quality of tea,
(b) to simplify our Tocklai tea tasting form, and
(c) to differentiate clones chemically.

The practical work of the project was carried out in 1966. Seven clones and a commercial *jat* of tea were selected and leaves from all the eight sources were manufactured on 12 occasions, alternately by C. T. C. and Orthodox methods, and the teas were sent under code to five experienced tasters (two in London, two in Calcutta and the Tocklai Manufacturing Adviser and Tea Taster) for evaluation of Colour, Brightness, Briskness, Strength and Quality and finally to place a cash value on each sample based on those liquor characters. The Biochemistry Department analysed green leaf, dried leaf and the made teas from each clone and the *jat* on all the 12 occasions, for 33 and 34 different chemical factors of the C. T. C. and Orthodox teas respectively. Unfortunately, for technical reasons one of the tasters' scores could not be finally utilised for analysis.

The large mass of chemical and tasting data are being analysed for the first time in the history of Tocklai on an IBM electronic computer at I.I.T. Kanpur. Some of the broad results revealed by the preliminary analyses of data are given below :

(i) Amongst the significant chemical factors affecting the Valuations of made teas of each taster, only 12 and 7 chemical factors for C.T.C. and Orthodox teas respectively, were found to be common for a majority of the tasters.

(ii) All the four tasters highly associated Valuation with Quality and or Briskness, both of C. T. C. and Orthodox teas.

(iii) The majority of tasters, highly associated Quality, both of C.T.C. and Orthodox teas, with Briskness.

Crop-Weather Studies

The main objective of this study is to study the effects of rainfall on yields and thereafter to develop a method for the prediction of annual crop.

Investigations into the effect of rainfall on the season's crop harvested during October to December (late crop) was extended over nine years

data (1957-65) with the continuous series of crop-weather records available from 34 tea estates of Upper Assam in the region where the average annual rainfall exceeded 2300 mm (90 inches). These 34 tea estates represented, by and large, the region extending over the whole of Lakhimpur district and the adjacent portion of the Sibsagar district.

Preliminary investigation of the 'within estate' source of variation showed that January to March and July to September rains had beneficial effects on the late crop but April to June rainfall showed an adverse effect.

Further, investigations into the effect of rainfall factors considered together with the crop harvested up to June (early crop) and that during July to September (main crop) on the late crop yield showed that, (i) rainfall during July to September had beneficial effects on the late crop and (ii) the late crop increased with the increase in main crop.

Detailed investigation is being continued.

Survey of Shade Trees

To study the influence of various shade species on the incidence of pests and diseases on tea bushes, severity of infestation of pests and diseases was observed during the rainy season (19.7.65 to 27.9.65 on a sample of tea bushes under each shade species in the six circles, namely, Nowgong, Jorhat, Nazira, Dibrugarh, Naharkatia and Panitola of the Assam valley. Estimated percentage areas of tea bushes affected by pests and/or diseases under different shade species by circles are given overleaf.

Estimated percentage areas of tea bushes affected by pests and/or diseases under different shade species

(Period of observation: 19.7.65 to 27.9.65)

Circle	Estimated percentage areas of tea bushes under				
	Albizzia odoratissima	*Albizzia procera*	*Albizzia chinensis*	*Delbergia assamica*	Over-all species
(1)	(2)	(3)	(4)	(5)	(6)
Nowgong	32.3	Not observed	36.9	Not observed	33.6
Jorhat	29.9	24.1	35.6	13.3	27.9
Nazira	27.2	36.4	12.4	17.6	27.1
Dibrugarh	7.3	15.9	17.0	8.3	13.8
Nahar-katia	23.2	24.5	21.3	16.0	22.5
Panitola	14.6	15.5	16.6	12.8	15.2
Over-all	26.4	21.8	26.5	12.9	23.5

It is seen from the above table that, over the circles, 26 per cent of tea bush areas were affected by pests and /or diseases under each of the species *Albizzia odoratissima* and *Albizzia chinensis*; the corresponding percentages under *Albizzia procera* and *Dalbergia assamica* were 22 and 13 respectively. However, the percentage area of tea bushes affected by pests and/or diseases varied between circles, between species and also according to the interplay of the factors.

However, it will be vital to examine whether or not the same trends of pests and diseases incidence on tea bushes under different shade species will be observed during their peak periods of attack and also the incidence of pests and diseases on tea bushes in full sun.

Sampling and Experimental Technique

Desirable and necessary specialised items of work, such as evolving ampling and experimental techniques for experimentation on tea so as

to minimise the cost and optimise the efficiency of experimentation could not be persued in practice during the year, although the paper plans are already in hand, because the Department was mainly confined to using desk calculators, in the absence of electronic computer facilities within easy reach of Tocklai.

Although much progress has been made by adopting appropriate statistical designs to increase the efficiency of experimentation, many questions peculiar to tea remain to be solved. Of particular and pressing urgency is the need to evolve sampling techniques at the field for the manufacture of miniature samples.

The ultimate aim for many experiments is to analyse results in terms of profit per hectare rather than as simple yields or valuations as is done at present.

Touring and Advisory

The Statistician and one member of the Department visited I. I. T., Kanpur in connection with the statistical analysis of data from the C5 experiment on the IBM electronic computer. The Statistician also visited eleven tea estates in Darjeeling and five in the Dooars in connection with different experiments; the Indian Statistical Institute, Calcutta University, IBM, ICT, Remington Rand of India Ltd. and C. C. Co. offices in Calcutta, and Lucknow to attend the Twenty First Annual Conference of the Indian Society of Agricultural Statistics.

Three members of the Department visited Bokahola T. E. weekly in connection with the uniformity trial. Mr. A. R. Sarkar, Statistical Assistant, attended the course on electronic computer at I. S. I., Calcutta from 15.10.67 to 15. 1. 68.

LIBRARY AND PUBLICATIONS DEPARTMENT

LIBRARY

General

The nucleus of the Library was founded in the Indian Museum in Calcutta in 1900, transferred to Tocklai in 1911 and by now it is one of the best special libraries in eastern India.

As a true special library, the bulk of the stock comprises of journals, some of which date back in unbroken sequence to 1900 which is indeed a rare collection.

Besides the scientific staff of the Station, Members of TRA and workers from other accredited institutions are free to utilise the library.

A large number of scientific and technical books have been received during the year under the Colombo Plan as gifts from the United Kingdom.

Currently the library subscribes to 114 scientific journals published in India or abroad and received 84 journals free or on exchange for our own publications.

The rapid increase of subscriptions to foreign scientific journals has proved embarassing and unless some way can be found of obtaining them on Foreign Aid programmes a number of important journals will have to be dropped from the subscription list.

Loan Service

Publications issued to the different departments during the year from the Central Library totalled 387 and 570 other publications were consulted in the library itself.

Reference Section

One set of the Encyclopaedia of Science and Technology (15 Volumes), one set of Everyman Encyclopaedia (12 Volumes), one set of the International Encyclopaedia of Science (4 Volumes), one set of the Shorter Oxford English Dictionery (2 Volumes) and other permanent reference books were added to the reference section of the library during the year.

Book Binding

A total of 553 books and volumes were bound from April 1967 to March 1968. Many of the old volumes bound between 1912 and 1940 require

rebinding, they having deteriorated because of the hot and humid summer conditions in Assam but unfortunately funds are not available to allow this project to go forward.

Reorganisation

Accessioning and Classification are in progress, and as soon as completed, will be followed by cataloguing and indexing in cards. One document printer has been purchased and one microfilm reader has been received on rental basis.

Reading Room

A new library reading room has been built as an adjunct to the library building.

Library Statistics

Books added during the year	—	97
Periodicals & Journals	--	1716
Pamphlets		594
Maps	--	4
Photocopies	—	5
Microcopies	--	31
Reprints	--	17
Translations	—	2

PUBLICATIONS

Tocklai publishes Annual Scientific reports; Two & A Bud, a quarterly journal for practical planters; Tea Encyclopaedia Serials on different aspects of tea growing and manufacture; Memoranda on specific aspects of tea and occasional scientific papers. These are printed and distributed to T. R. A. Members free of cost and sold to Non-Members all over the world.

In addition, the Conference Proceedings, the Summarised Annual Scientific Report and other papers are published, for restricted distribution.

The following publications were issued by the Station during 1967 68:

(1) "Two & A Bud" (Newsletter) Vol. 14. Nos. 1.2.3 & 4.

(2) Annual Scientific Report for 1966.

(3) Wall-chart 'Recommendations for the control of Pests and Diseases of Tea & Shade Trees'.

(4) Summarised Annual Scientific Report for 1967. (restricted circulation.)

(5) Soil Survey of Jorhat District 1967/68, Part 1.
(6) Proceedings of the Twenty Third Conference held at Tocklai 7th 8th & 9th November 1967. (restricted circulation)
(7) Meteorological Records- North East India, Tea areas (restricted circulation.)

Tea Encyclopaedia Serials (Revised)

(8) 1/2 Encyclopaedia of Tea A. 1.
(9) 23/1 Stump Planting of Shade Trees F. 1.
(10) 74/4 List of available publications A.5.
(11) 75/7 Index of Encyclopaedia of Tea Serials issued to May 1967 A-1.
(12) 123/2 General Index of Encyclopaedia of Tea A. 1.
(13) 131/2 General Index of "Two & A Bud" Vol. 1. No. 1 to 13, No. 4, December 1966 A. 5.
(14) 122/3 Classified Index of Encyclopaedia of Tea A. 1.
(15) 155/2 Index of Articles published in "Two & A Bud" 1951-1966 A.5.
(16) 45 1 Fermentation Floors and Racks for Fermenting Leaf by the Conventional Method K. 5.
(17) 69 2 Tea Tasting Terms K. 10.

Tea Encyclopaedia Serials (New)

(18) 171 Power Spraying 1. 4.
(19) 172 Conventional Roller/C. T. C. Manufacture K. 1.

J. N. Sharma
Librarian and Publication In-charge

APPENDIX A

List of Experiments
Conducted on Member Estates
By
the Advisory Department

South Bank

Project	Site (T.E.)	Index	Year of starting
Rehabilitation of land	Sangsua	AS 45	1963
	Duklingia	AS 48	1964
	Ghillidary	AS 49	1964
	Hansara	AS 50	1964
N P K Manuring	Murmuria	AS 11	1956
	Khoomtaie	AS 29	1959
	Ligri Pookri	AS 39	1961
	Katonibari	AS 44	1963
	Hunwal	AS 51	1964
	Dirok	AS 63	1965
Nitrogenous fertiliser	Sycotta	AS 56	1954
	Sagmootea	AS 62	1965
	Joonktollee	AS 64	1966
	Nahor Habi	AS 65	1966
	Furkating	AS 69	1966
	Halmirah	AS 71	1966
	Cinnamara	AS 77 *	1966
	Meleng	AS 78 *	1966
	Borsillah	AS 79 *	1966
	Joonktollee	AS 82	1967
	Gabroo Purbut	AS 83	1967
Pruning	Cinnamara	AS 12	1957
	Duklingia	AS 13	1958
	Dufflating	AS 84	1967
Irrigation	Amluckie	AS 52	1963
	Towkok	AS 66	1966
	Borahi	AS 67	1966

Project	Site (T E.)	Index	Year of starting
Irrigation (cont)	Gorunga	AS 68	1966
	Gabroo Purbati	AS 70	1966
	Dejoo Valley	AS 72	1966
	Dejoo Valley	AS 73	1966

North Bank, Assam

Project	Site (T. E.)	Index	Year of starting
Rehabilitation of land	Tarajuli	AN 46	1964
	Deckiajuli	AN 47	1964
Nitrogenous fertiliser	Halem	AN 3	1933
	Nahorani	AN 59	1964
	Gingia	AN 80 *	1966
	Shakomato	AN 81 *	1966
Pruning	Phulbari	AN 58	1964
	Ghoirallie	AN 60	1965
	Kolony	AN 76	1966
Irrigation	Balipara	AN 55	1963
	Sessa	AN 61	1965
	Durrung	AN 74	1966
	Mazbat	AN 75	1966
Cultivation and weed control	Halem	AN 15	1958
	Halem	AN 31	1960

* Effect of nitrogen with and without liming

Cachar, Assam

Project	Site (T. E.)	Index	Year of starting
Rehabilitation of land	Koomber	C 25	1964
N P K Manuring	Isa Bheel	C 26	1966
	Hattikhira	C 27	1966
	Longai	C 28	1966
	Silcoorie	C 32	1967
Nitrogenous fertiliser	Pallorbund	C 29	1966
	Dewan	C 30	1966
Pruning	Coombergram	C 21	1961
	Longai	C 22	1962
	Chandighat	C 23	1962
	Silcoorie	C 24	1962
	Pallorbund	C 33	1967
	Dewan	C 34	1967
Irrigation	Roopacherra	C 31	1966
Shade and Manuring	Coombergram	C 20	1962

Dooars & Terai, West Bengal

Project	Site (T. E.)	Index	Year of starting
Rehabilitation of land	Bhogotpore	D 27	1964
	Grassmore	D 28	1964
N P K Manuring	Kalchini	D 1	1954
	Needam	D 30	1963
Nitrogenous fertiliser	Baradighi	D 33	1966
Pruning	Chuapara	D 2	1955
	Baradighi	D 4	1954

Project	Site (T. E.)	Index	Year of starting
Pruning	Sam Sing	D 34	1966
	New Chumta	TR 2	1966
Irrigation	Baintgoorie	D 31	1965
	Rajabhat	D 32	1965
	Gopalpore	D 35	1966
	New Chumta	TR 1	1966
Cultivation and Weed Control	Bhatpara	D 10	1957
	Chuapara	D 11	1957
Shade and Manuring	Nya Sylee	D 24	1962
Shade	Nya Sylee	D 9	1958

Darjeeling, West Bengal

Project	Site (T.E.)	Index	Year of starting
N P K Manuring	Tumsong	Dj 22	1965
	Sungma	Dj 23	1965
Nitrogenous fertiliser	Singell	Dj 26	1966
	Marybong	Dj 28	1966
	Lingia	Dj 29	1967
Pruning	Lingia	Dj 21	1963
	Phoobsering	Dj 24	1965
	Goomtee	Dj 25	1966
	Margaret's Hope	Dj 27	1966
Plucking	Mim	Dj 18	1961
Shade and Manuring	Nagri Farm	Dj 19	1961

APPENDIX B

List of Experiments
Conducted in the Member Estates
By
the Other Departments

Agriculture Department

	Experiment	Location of Estate	Site (T. E.)	Index No.	Year started
1.	Rehabilitation trial with grasses & Cover crop.	South Bank, Assam	Hunwal T. E.	S 1	1966 1967
2.	Rehabilitation trial with grasses by manuring	,, ,, ,,	,,	S 2	1966 1967

Soils Department

	Experiment	Location of Estate	Site (T. E.)	Index No.	Year started
1.	Reclamation of Sub-Acid Soils	Dooars, West Bengal	Birpara	D. 401	1966
2.	,,	,,	Bundapani	D. 402	1966
3.	Trials of Clones on Sub-Acid Soils	,,	Birpara	--	1967
4.	Reclamation of Sub-Acid Soils	North Bank, Assam	Nilpur	—	1967

Botany Department

	Experiment	Location of Estate	Site (T. E.)	Index No.	Year started
1.	Trial of biclonal seed stocks	South Bank, Assam	Hapjan	AS 200	1963
2.	,,	,,	Tengpani	AS 201	1963
3.	,,	,,	Tengpani		1965
4.	,,	,,	Kakajan	AS 206	1966
5.	,,	North Bank, Assam,	Nahorani	AS 202	1963
5.	,,	,,	Sonabheel	AS 203	1964
7.	,,	,,	Durrung	AS 204	1965
8.	,,	,,	Bhooteachang	AS 205	1965
9.	,,	Cachar, Assam	Jellalpore	C 200	1963
10.	,,	,,	Dewan Group of estates	C 201	1966
11.	,,	Dooars, West-Bengal	Sathkyah	D 200	1962
12.	,,	,,	Bhatkawa	D 201	1962
13.	,,	,,	Bhatkawa	D 206	1965
14.	,,	,,	Hantapara	D 202	1964
15.	,,	,,	Meenglas	D 203	1964
16.	,,	,,	Hasimara	D 204	1964
17.	,,	,,	Rydak	Dj 205	1965
18.	,,	Darjeeling,	Mim	Dj 200	1961
19.	,,	West Bengal	Ging	Dj 201	1965
20.	Effect of shade and nutrients	South Bank, Assam	Murmuria	AS 207	1965
21.	Observation plots	,,	Bazaloni	—	1962
22.	,,	,,	Ducklingia	—	1963
23.	,,	North Bank, Assam	Nonaipara	—	1966
24.	,,	Terai, W. Bengal	New Chumta	—	1963

Entomology Department

	Experiment	Location of Estate	Site (T.E.)	Index No.	Year started
1.	Scarlet mite	South Bank, Assam	Bokahola	N 7	1967
2.	Ecological studies on the mite pests of tea	,,	Murmuria	N 7	1966

Mycology Department

Experiment	Location of Estate	Site (T.E.)	Index No.	Year started
1. Effect of Chemical treatments on disease control	South Bank, Assam	Dahingeapar	—	1967
2. Chemical control of *Corticium invisum*	,,	Suffry	—	1967
3. i) Chemical control of *Corticium theae*	,,	Cinnamara		1967
ii) Efficiency of different spraying equipment				
4. Chemical control of purple root rot.	North Bank, Assam	Baghmari	—	1965
5. Effect of top-spraying and Indopasting on disease incidence	Darjeeling West Bengal	Runglee Runghot	—	1962
6. ,,	,,	Chamong	—	1962
7. Observation on the relation between N.P.K manuring and Thorny blight	,,	Sungma	—	1966
8. Effect of chemical application in relation to disease development.	,,	Happy Valley	—	1966
9. BAS 20 in collaboration with Botany	South Bank Assam	Murmuria	—	1967

Pesticide Department

Experiment	Location of Estate	Site (T.E.)	Index No.	Year started
1. Red spider prophylactic spraying experiment	South Bank, Assam	Dahingeapar	—	1967
2. Red spider Palliative spraying experiment	,,	Dahingeapar	—	1967
3. Pink and Purple mite Palliative spraying experiment	,,	Deha		1967
4. Scarlet mite Palliative spraying experiment	,,	Teok	--	1967
5. Joint action of pesticides for control of combined infestation of Red spider, Scarlet and Pink mites in one area	,,	Teok	--	1967
6. Joint action of pesticides for control of combined infestation of Red spider, Scarlet mite and Scales in one area	Darjeeling, West Bengal	Balasun	—	1967
7. Joint action of pesticides for control of combined infestation of Red spider, Scarlet	Terai, W. Bengal	Merryview	—	1967

	Experiment	Location of Estate	Site (T. E)	Index No.	Year started
	and Purple mite in one area				
8.	Joint action of pesticides for control of combined infestation of Red spider, Scarlet mite and Thrips in one area	Terai, W. Bengal	Sahabad	—	1967
9.	Helopeltis trial Palliative	,,	Gulma	—	1967
10.	Looper trial	South Bank, Assam	Doyang	—	1967
11.	Cockchafer trial	Dooars, W. Bengal	i) Bhatkawa	—	1964 continued
		,,	ii) Rungamuttee	—	1967
12.	Blister blight trial	Darjeeling, West Bengal	Goomtee	—	1967

Engineering Department

	Experiment	Location of Estate	Site (T.E.)	Index No.	Year started
1.	Continuous Tray Drier	South Bank, Assam	Hunwal	—	1967
2.	Continuous Fermenting cum Drying Machine	,,	Duklingia	—	,,
3.	Experimental 15" Aluminium Rotorvane	,,	Kamalpur	—	,,

Experiment	Location of Estate	Site (T. E.)	Index No.	Year started
4. 76 cm (30") Disc Roller	South Bank, Assam	Kotalgoorie	—	1967
	Darjeeling, West Bengal	Ging	—	,,
5. Cone Attachment for the 38 cm (15") Rotorvane	Cachar, Assam	a) Dewan and then Serispore	—	
	Dooars, West Bengal	b) Rungamuttee	—	,,
6. Cone Attachment with sleeve for 38 cm (15") Rotorvane	South Bank, Assam	Tengpani	—	,,
7. Manual Plucking Aids	,,	a) Tengpani	—	,,
	Darjeeling, West Bengal	b) Goomtee	—	,,
		c) Soom	—	,,
	,,	d) Runglee Rungliot	—	,,
		e) With C.A.O. West Bengal		,,
		f) With C.A.O. West Bengal	—	,,

Statistics Department

Experiment	Location of Estate	Site (T. E.)	Index No.	Year started
1. Uniformity trial	South Bank, Assam	Bokahola	—	1963
2. Uniformity trial	Darjeeling, West Bengal	Nagri Farm	—	1964
3. Long term defoliation experiment	Dooars, West Bengal	Nya Sylee	—	1963
	,,	Bhogotpore	—	1963
	,,	Jiti	—	1963
	,,	Hope	—	1963
	,,	Kurti	—	1963

APPENDIX - C

PUBLISHED PAPERS AND PAPERS IN THE PRESS

1. Banerjee, B. (1967). Seasonal changes in the distribution of the millipede, *Cylindroiulus punctatus* (Leach), in decaying logs and soil. *J. Anim Ecol.* **36**, 171-177.

   (Abs. The proportions of the population of *Cylindroiulus punctatus* in the different soil layers and in logs lying on the soil vary during the year. From March to June, adults move out of the mineral soil into the L + F + H layers and into oak logs. Here, under the bark, they oviposit. At the end of breeding season, i. e. during September and October, the adults migrate from the logs into the L + F + H layers and eventually into the mineral soil where they overwinter. Eggs and first three instars are found beneath the bark, while the rest of the immature instars (fourth to seventh) are passed in the litter.)

2. Banerjee, B. (1967). Distribution of alkaline phosphatase in the castes of the termite, *Odontotermes redemanni* (Wasmann), and its role in caste formation. *Insectes Sociaux* **14** (1), 51-56.

   (Abs. The distribution of Alkaline Phosphatase in the brain cells and digestive tracts of different castes of *Odontotermes redemanni* (Wasmann) is very specific. In the larvae three different patterns of phosphatase distribution are evident, one each resembling the reaction pattern in the worker, soldier and reproductive castes. Caste remains undifferentiated during early embryogenesis Workers carry the exudate containing inhibitory and/or stimulator substance from the queen to the undifferentiated larvae in nurseries. Selective application of the exudate determines the future courses of development of the larvae which then show phosphatase reactions specific to the castes they are developing into)

3. Banerjee, B. (1967). Diurnal and seasonal variations in the activity of the millipedes, *Cylindroiulus punctatus* (Leach), *Tachypodoiulus niger* (Leach) and *Polydesmus angustus* Latzel. *Oikos* **18**, 141- 144.

   (Abs. Trapping of natural populations of *Cylindroiulus punctatus*, *Tachypodoiulus* and *Polydesmus angustus* showed that these millipedes are most active during darkness from one hour after sunset till one hour before sunrise. In summer (April-June) they become

active in the afternoon in full daylight. It is suggested that this is made possible because millipedes develop a resistance to desiccation during this period. Seasonal variation in numbers trapped is not significantly correlated to either temperature or rainfall, but is associated with the breeding cycle of the millipedes.)

4. Das, G. M. and Das, S. C. (1967). Effect of temperature and humidity on the development of tea red spider mite, *Oligonychus coffeae* (Nietner). *Bull ent. Res.* 57 (3), 433-436.

(Abs. The development of *Oligonychus coffeae* (Nietner) is affected by temperature and humidity. The pre-oviposition oviposition and post-oviposition periods of adult females at 75-80% relative humidity vary inversely with temperature. The average number of eggs laid per female likewise varies inversely with temperature.

No eggs hatch when incubated at 34°C, irrespective of humidity, or at17% R. H., irrespective of temperature. A combination of temperatures and relative humidities within the ranges 20-30 °C, and 49-94% R. H. provide the optimum conditions for incubation. When the eggs are exposed daily on five days to high temperatures (37 and 40 °C) for six hours at 72-94% R. H. and then transferred to room-condition, the percentage of eggs hatching is considerably reduced.

The mean incubation period of eggs and the mean duration of immature stages are reduced with the rise of temperature. At 32 °C, larval mortality is very high.)

5. Banerjee, B. Aggregating behaviour of the caterpillars of *Andraca bipunctata* Wlk. *Science and Culture* (communicated).

6. Banerjee, B. and Kakoty, N. N. Biology and control of *Ragmus importunitas* Distants. *Ind. J. Ent.* (communicated.)

7. Bezbaruah, H. P. An evaluation of preparatory procedures for leaf-tip chromosome spreads of the tea plant (*Camellia sinensis*). *Stain Technology*. (In the press)

8. Bezbaruah, H. P. Genetic improvement of tea in North East India-its problems and possibilities. *National Symposium on Accelerating Improvement of India's Plant Resources*, I. A. R. I. (New Delhi).

9. Hadfield, W. Temperature, leaf pose and productivity of the tea bush. *Nature* (In the press)

10. Hadfield, W. Leaf pose and light penetration in the tea bush. *Journal of Applied Ecology.* (in the press)

11. Rahman, F. Effect of Mulches, Levels of Nitrogen and Irrigation on Nutrient uptake Moisture Depletion Pattern and Certain Soil Properties in a Cauliflower Field. *Indian Agriculturist* (In the press)

Appendix—D.

Summary of Meteorological observations during 1967

Table 1. Tocklai (Mid Assam) (26°47'N, 94°12'E, 86·6 metres a. m. s. l.

Month 1967	Daily temperature °C					Rainfall		Daily Sunshine in hours	Daily soil temperature (under grass) °C			Monthly evaporation	
									Depth				
	Mean max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.03 mm and above		5 cm	15 cm	30 cm	Open pan in mm	Penman in mm
January	24.1	9.8	17.0	26.4	6.8	4.1	3	7.3	19.7	19.0	19.7	46.5	67.4
	(22.4)	(9.2)	(15.8)			(20.5)	(4)	(5.8)	(18.4)	(18.4)	(19.0)		
February	24.3	13.1	18.7	28.0	7.9	63.8	9	6.3	21.1	20.2	20.6	56.0	82.7
	(24.1)	(11.8)	(18.0)			(33.2)	(7)	(6.1)	(20.8)	20.0)	(20.2)		
March	25.8	15.8	20.8	30.4	11.5	83.8	18	6.0	23.1	22.4	22.5	80.6	114.9
	(27.5)	(15.4)	(21.4)			(82.8)	(11)	(6.6)	(24.1)	(23.0)	(23.0)		
April	29.1	18.8	24.0	32.8	15.2	138.7	12	6.1	26.5	25.4	25.2	99.0	141.5
	(28.7)	(18.9)	(23.8)			(187.7)	(17)	(5.8)	(27.1)	(25.8)	(25.6)		
May	29.7	22.1	25.9	35.4	18.7	230.4	22	5.6	28.8	27.6	27.3	89.9	155.7
	(29.9)	(21.7)	(25.8)			(285.9)	(21)	(4.9)	(28.5)	(27.5)	(27.4)		
June	30.5	24.0	27.2	34.6	20.7	402.6	25	4.1	29.8	29.1	29.0	96.0	148.9
	(31.5)	(24.0)	(27.7)			(324.9)	(23)	(4.4)	(30.4)	(29.5)	(29.2)		
July	31.7	25.2	28.4	34.6	23.6	444.5	25	4.0	30.6	29.8	29.8	74.4	158.1
	(32.2)	(24.5)	(28.4)			(384.5)	(25)	(4.8)	(31.4)	(30.5)	(30.4)		
August	32.9	25.4	29.2	35.3	23.5	258.1	20	6.9	32.6	31.4	31.2	108.5	130.4
	(32.0)	(24.5)	(28.2)			(339.9)	(23)	(5.0)	(31.4)	(30.5)	(30.4)		
September	31.0	23.9	27.4	34.0	22.5	235.5	24	5.1	30.8	30.2	30.4	84.0	133.7
	(31.2)	(23.8)	(27.5)			(254.1)	(19)	(5.0)	(31.0)	(30.2)	(30.2)		
October	29.3	20.6	25.0	31.1	17.7	76.2	15	6.6	28.2	27.8	28.0	65.1	121.1
	(29.3)	(20.9)	(25.1)			(116.0)	(12)	(5.5)	(28.6)	(28.0)	(28.2)		
November	25.8	14.0	19.9	28.2	10.8	11.9	2	7.7	23.2	23.0	23.8	54.0	83.2
	(26.2)	(15.1)	(20.6)			27.4)	(4)	(6.1)	(24.0)	(23.6)	(24.5)		
December	23.5	11.8	17.6	25.6	9.4	10.5	4	5.4	20.0	19.6	20.5	31.0	56.1
	(23.3)	(10.6)	(17.0)			(10.7)	(3)	(5.9)	(20.2)	(19.8)	(20.8)		

Notes : 1. Data in brackets show previous averages
2. Soil temperature at different depths are the mean of morning and afternoon readings
3. "Penman in mm" equals the Penman estimate of evaporation from an open water surface, Eo.

Table 2. Silcoorie (Cachar) (24°50'N, 92°48'E, 39·6 meters a. m. s. l.)

Month 1967	Daily temperature °C					Rainfall		Daily Sunshine in hours	Daily soil temperature (under grass) °C			Monthly evaporation	
	Mean max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.03 mm and above		Depth			Open pan in mm	Penman in mm
									5 cm	15 cm	30 cm		
January	26.0	12.8	19.4	28.0	8.1	38.5	2	7.5	21.2	20.8	21.1	63.2	83.2
	(26.1)	(11.0)	(18.6)			(21.4)	(2)	(8.0)	(21.5)	(20.8)	(21.4)		
February	27.0	13.9	20.4	30.4	8.3	19.8	3	8.8	23.9	22.9	22.8	83.2	106.6
	(27.2)	(12.8)	(20.0)			(52.3)	(4)	(7.9)	(23.2)	(22.1)	(22.4)		
March	28.3	16.9	22.6	30.5	11.6	113.9	12	7.2	25.9	24.8	24.6	115.0	137.7
	(30.5)	(16.5)	(23.5)			(100.7)	(7)	(7.8)	(26.6)	(25.2)	(25.2)		
April	?	19.0	?	?	15.3	175.1	12	7.1	27.4	26.6	26.5	87.9	148.3
	(32.4)	(20.5)	(26.4)			(217.4)	(12)	(7.9)	(29.8)	(28.3)	(28.2)		
May	32.7	22.8	27.8	37.2	19.2	196.9	29	6.8	29.9	28.5	(28.2)	116.6	176.2
	(31.9)	(22.8)	(27.4)			(397.3)	(20)	(6.4)	(30.6)	(29.3)	(29.2		
June	31.8	23.9	27.8	35.6	21.1	549.5	27	4.4	30.1	29.3	29.4	107.1	146.4
	(31.5)	(24.4)	(28.0)			(612.3)	(25)	(4.0)	(30.4)	(29.4)	29.4)		
July	32.3	25.1	28.7	35.7	23.9	599.2	27	4.7	31.0	30.1	(30.0	110.2	154.3
	(32.1)	(25.0)	(28.6)			(529.1)	(27)	(4.5)	(31.3)	(30.4)	(304		
August	33.5	25.3	29 4	35.8	23.3	406.7	23	6.7	32.4	31.2	31..2	132.7	136.0
	(32.2)	(25.0)	(28.6)			(408.2)	(25)	(4.8)	(31.4)	(30.6)	(30.6)		
September	32.2	24.5	28.4	35.0	23.2	365.9	20	5.2	31.4	30.5	30.6	126.3	139.7
	(32.4)	(24.5)	(28.4)			(357.4)	(18)	(5.6)	(31.2)	(30.4)	(30.4)		
October	31.2	21.2	26.2	33.3	17.1	143.0	9	7.5	28.8	28.2	28.4	89.8	139.0
	(31.0)	(22.4)	(26.7)			(224.6)	(11)	(6.4)	(29.3)	(28.8)	(29.0)		
November	29.1	15.4	22.2	31.8	11.9	2.0	1	8.6	26.0	25.5	25.9	72.4	101.5
	(29.3)	(16.9)	(23.1)			(14.8)	(2)	(8.1)	(25.9)	(25.6)	(26.0)		
December	27.2	12.1	19.6	29.3	9.7	0.0	0	8.2	23.0	22.8	22.9	66.0	80.5
	(26.9)	(12.6)	(19.8)			(9.6)	(1)	(7.9)	(22.8)	(22.4)	(23.0)		

Notes :

1. Data in brackets show previous averages
2. Soil temperature at different depths are the mean of morning and afternoon readings
3. "Penman in nm" equals the Penman estimate of evaporation from an open water surface, Eo
4. ? indicates data not available

Table 3. Nagrakata (Dooars) (26°54'N, 88°55'E, 228·6 meters a. m. s. l.)

Month 1967	Daily temperature °C					Rainfall		Daily Sunshine in hours	Daily soil temperature (under grass) °C			Monthly evaporation	
	Mean max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.03 mm and above		Depth			Open pan in mm	Penman in mm
									5 cm	15 cm	30 cm		
January	25.0	10.5	17.8	27.0	7.5	0.0	0	8.8	18.5	?	20.2	101.4	80.8
	(23.8)	(10.5)	(17.2)			(12.9)	(2)	(8.4)	(17.9)	(17.9)	(19.2)		
February	26.5	13.4	20.0	28.7	9.3	0.0	0	8.0	21.3	?	22.0	118.4	100.8
	(25.9)	(13.4)	(19.6)			(28.6)	(3)	(7.7)	(20.1)	(19.6)	(20.6)		
March	27.1	15.5	21.3	31.2	11.5	141.6	12	6.5	23.0	?	23.3	151.9	126.7
	(29.4)	(16.3)	(22.8)			(38.6)	(4)	(7.9)	(23.5)	(22.8)	(23.4)		
April	30.0	19.2	24.6	33.0	16.6	84.3	10	6.7	25.0	24.8	25.0	151.2	156.5
	(31.6)	(20.2)	(25.9)			(112.2)	(9)	(7.4)	(27.2)	(26.3)	(26.6)		
May	30.4	21.3	25 8	34.9	17.8	324.2	20	7.2	27.8	27.4	27.2	146.0	173.6
	(31.1)	(21.7)	(26 4)			(273.0)	(19)	(6.6)	(28.6)	(27.6)	(28.0)		
June	30.0	22.5	26.2	32.2	20.5	832.0	25	3.9	28.1	28.8	28.0	117.6	143.5
	(30.5)	(23.4)	(27 0)			(901.7)	(26)	(3.8)	(28.6)	(27.8)	(28.2)		
July	30.3	23.8	27.0	33.4	21.9	1409.9	25	4.2	28.9	27.7	27.7	116.6	147.4
	(30.3)	(23.7)	(27.0)			(994.0)	(27)	(3.4)	(29.1)	(28.4)	(28.6)		
August	1.5	23.9	27.7	34.9	22.6	472.6	27	4.8	29.4	30.7	29.2	115.6	135.5
	(330.3)	(23.6)	(27.0)			(820.7)	(28)	(3.9)	(29.2)	(28.4)	(28.8)		
September	30.6	22.7	26.6	33.8	20.6	555.8	23	5.6	28.6	30.8	28.7	109.5	135.6
	(30.7)	(22.8)	(26.8)			(523.6)	(22)	(5.4)	(29.0)	(28.8)	(28.8)		
October	30.2	18.0	24.1	32.3	14.3	236.0	9	9.1	26.2	30.6	27.0	116.2	138.1
	(29.8)	(19 6)	(24.7)			(154.4)	(10)	(7.6)	(27.0)	(27.0)	(27.4)		
November	26.7	13.0	19.8	29.5	10.4	8.2	4	8.7	21.2	21.8	23.1	97.6	94 2
	(27.2)	(14.7)	(21.0)			15.5)	(3)	(8.6)	(22.6)	(22.8)	(24.0)		
December	24.2	12.6	18.4	26.4	3.0	3.1	3	7.1	19.9	20.3	21.2	92.3	70.8
	(24.8)	(11.2)	(18.0)			(4.8)	(2)	(8.5)	(19.5)	(19.6)	(21.0)		

Notes :
1. Data in brackets show previous averages
2. Soil temperature at different depths are the mean of morning and afternoon readings
3. "Penman in mm" equals the Penman estimate of evaporation from an open water surface, E_o
4. ? indicates data not available

Table 4. Nagri Farm (Darjeeling) (26°55'N, 88°12'E, 1,158·2 meters a. m. s.l.)

Month 1967	Daily temperature °C					Rainfall		Daily Sunshine in hours	Daily soil temperature (under grass) °C			Monthly evaporation	
	Mean max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.03 mm and above		Depth			Open pan in mm	Penman in mm
									5 cm	15 cm	30 cm		
January	16.2	8.5	12.4	18.9	6.5	0.0	0	7.9	15.0	13.4	14.7	65.3	67.8
	(15.6)	(7.9)	(11.8)			(24.3)	(2)	(6.6)	(12.8)	(12.5)	(13.8)		
February	17.0	10.3	13.6	21.7	6.4	0.0	0	7.0	16.8	15.2	16.0	68.5	79.9
	(17.3)	(9.9)	(13.6)			(21.4)	(4)	(6.1)	(14.6)	(13.8)	(14.5)		
March	17.7	11.4	14.6	21.0	7.5	167.9	12	4.9	17.2	16.0	16.8	81.0	93.8
	(21.0)	(12.9)	(17.0)			51.7))	(4)	(7.1)	(18.4)	(17.0)	(17.2)		
April	21.0	14.8	17.9	25.1	11.9	93.2	12	5.4	20.4	18.6	18.8	92.3	120.4
	(23.7)	(15.9)	(19.8)			(80.4)	(9)	(6.0)	(21.4)	(20.0)	(20.0)		
May	22.7	16.9	19.8	28.9	14.5	63.9	19	5.6	23.8	21.6	21.6	80.5	137.3
	(23.9)	(17.2)	(20.6)			(207.6)	(19)	(5.2)	(23.2)	(21.9)	(21.8)		
June	23.3	18.5	20.9	24.9	16.4	234.0	24	2.1	24.2	22.4	22.8	54.6	163.8
	(24.0)	(18.8)	(21.4)			(427.1)	(25)	(2.9)	(24.4)	(23.4)	(23.1)		
July	23.9	19.3	21 6	27.4	17.9	873.5	25	3.1	25.2	23.5	23.8	60.1	140.9
	(24.0)	(19.2)	(21.6)			(668.3)	(27)	(2.4)	(24.6)	(23.8)	(23.7)		
August	26.8	19.5	23.2	28.8	18.2	305.5	26	4.5	26.1	24.6	24.7	75.8	122.7
	(24.3)	(19.1)	(21.7)			(529.4)	(26)	(3.0)	(25.0)	(24.0)	(24.0)		
September	25.8	18.0	21.9	28.3	16.5	338.1	19	4.5	24.8	23.2	23.8	68.3	110.9
	(24.2)	(18.3)	(21.2)			(313.8)	(20)	(4.3)	(24.2)	(23.3)	(23.4)		
October	24.5	14.2	19.4	27.0	12.2	26.2)	3	8.3	23.0	21.2	22.0	82.3	114.6
	(22.9)	(15.7)	(19.3)			(88.5)	(8)	(6.5)	(21.6)	(21.1)	(21.7)		
November	20.0	10.6	15.3	22.4	6.4	16.3	7	6.4	17.6	16.4	18.2	53.8	70.4
	(20.0)	(11.8)	(15.9)			(14.7)	(2)	(7.2)	(17.6)	(17.2)	(18.4)		
December	18.0	9.1	13.6	21.2	7.8	1.0	1	5.1	14.6	13.4	15.3	32.5	58.1
	(17.2)	(9.2)	(13.2)			(4.0)	(1)	(7.0)	(14.6)	(14.1)	(15.5)		

Notes :
1. Data in brackets show previous averages
2. Soil temperature at different depths are the mean of morning and afternoon readings
3. "Penman in mm" equals the Penman estimate of evaporation from an open water surface, Eo

Per cent Relative humidity

Table 1 (*a*) *Tocklai*

Hours of observations I. S. T.	Jan.	Feb.	Mar.	Apl.	May.	Jun.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
O613	95 (97)	94 (95)	93 (93)	88 (91)	92 (93)	93 (93)	93 (94)	93 (95)	96 (96)	97 (97)	95 (97)	96 (97)
1313	48 (58)	52 (55)	57 (55)	51 (63)	70 (71)	79 (75)	77 (75)	70 (75)	74 (75)	69 (73)	56 (65)	60 (61)

Table 2 (*a*) *Silcoorie*

Hours of observations I. S. T.	Jan.	Feb.	Mar.	Apl.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
0619	99 (98)	97 (96)	95 (93)	90 (90)	88 (91)	94 (95)	95 (95)	94 (95)	97 (95)	96 (97)	98 (97)	98 (98)
1391	50 (46)	44 (45)	50 (43)	55 (54)	64 (67)	76 (76)	73 (75)	67 (73)	73 (71)	63 (68)	49 (55)	45 (48)

Note : Data in brackets show previous averages

Per cent Relative humidity

Table 3(a) Nagrakata

Hours of observations I. S. T.	Jan.	Feb.	Mar.	Apl.	May.	Jun.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
0634	76	74	80	76	86	94	95	92	93	84	76	91
	(83)	(81)	(74)	(75)	(87)	(95)	(96)	(96)	(95)	(89)	(85)	(86)
1334	50	45	55	52	66	81	84	79	73	59	49	55
	(50)	(51)	(46)	(53)	(70)	(83)	(84)	(82)	(78)	(68)	(60)	(55)

Table 4(a) Nagri Farm

Hours of observations I. S. T.	Jan.	Feb.	Mar.	Apl.	May.	Jun.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
0637	57	64	78	69	81	94	93	90	89	71	70	84
	(72)	(70)	(62)	(68)	(79)	(92)	(94)	(95)	(89)	(78)	(70)	(70)
1337	60	62	84	72	85	91	91	85	86	77	74	86
	(70)	(66)	(59)	(67)	(82)	(90)	(91)	(89)	(87)	(81)	(76)	(71)

Note : Data in brackets show previous averages

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